Environmental radioactivity in the Faroes in 1982

Aarkrog, A.; Dahlgaard, Henning; Hallstadius, L.; Holm, E.; Hansen, Heinz Johs. Max; Lippert, Jørgen Emil

Publication date:
1983

Document Version
Publisher's PDF, also known as Version of record

Risø-R-488

RISØ

Risø-R-488

Environmental Radioactivity in the Faroes in 1982

A. Aarkrog, H. Dahlgaard, L. Hallstadius, E. Holm, H. Hansen, and J. Lippert

Risø National Laboratory, DK-4000 Roskilde, Denmark
July 1983

Risø-R-488

ENVIRONMENTAL RADIOACTIVITY IN THE FAROES IN 1982

A. Aarkrog, H. Dahlgaard, L. Hallstadius*, E. Holm*, H. Hansen, and J. Lippert

*University of Lund, Sweden

Abstract. Measurements of fallout radioactivity in the Faroes in 1982 are presented. Strontium-90 (and ^{137}Cs in most cases) was determined in regularly collected samples of precipitation, grass, milk, fish, sea water, bread and drinking water. In addition, analyses were made of spot samples of potatoes, sea plants, eggs, and human bone. Estimates are given of the mean contents of ^{90}Sr and ^{137}Cs in the human diet in the Faroes in 1982. In Appendix the results from a sampling of sea water and biota along the English and the Scottish coasts are given.

INIS Descriptors

[0] DIET, ENVIRONMENT, EXPERIMENTAL DATA, FAROE ISLANDS, FISHES, FOOD, FOOD CHAINS, GLOBAL FALLOUT, MILK, PLANTS, RADIOACTIVITY, SEA WATER, SHEEP, TABLES, UNITED KINGDOM

[1] ATMOSPHERIC PRECIPITATIONS, BONE TISSUES, DRINKING WATER, MAN, STRONTIUM 90

[2] CESIUM 137

[3] PLUTONIUM

UDC 614.73 (491.2)

July 1983

Risø National Laboratory, DK-4000 Roskilde, Denmark

ISBN 87-550-0951-4
ISSN 0106-2840

Risø Repro 1983

CONTENTS

ABBREVIATIONS AND UNITS

J: joule: the unit of energy; 1 J = 1 Nm (= 0.239 cal)
Gy: gray: the unit of absorbed dose = 1 J kg^{-1} (= 100 rad)
Sv: sievert: the unit of dose equivalent = 1 J kg^{-1} (= 100 rem)
Bq: becquerel: the unit of radioactivity = 1 s^{-1} (= 27 pCi)

cal: calorie = 4.186 J
rad: 0.01 Gy
rem: 0.01 Sv
Ci: curie: $3.7 \cdot 10^{10}$ Bq (= $2.22 \cdot 10^{10}$ dpm)

T: tera: 10^{12}
G: giga: 10^{9}
M: mega: 10^{6}
m: milli: 10^{-3}
μ: mikro: 10^{-6}
n: nano: 10^{-9}
p: pico: 10^{-12}
f: femto: 10^{-15}
a: atto: 10^{-18}

cap: caput: (per individual)
TNT: trinitrotoluol; 1 Mt TNT: nuclear explosives equivalent to 10^{9} kg TNT.

cpm: counts per minute
dpm: disintegrations per minute
OR: observed ratio
CF: concentration factor
FP: fission products
μR: micro-roentgen, 10^{-6} roentgen
S.U.: pCi ^{90}Sr (g Ca)$^{-1}$
O.R.: observed ratio
M.U.: pCi ^{137}Cs (g K)$^{-1}$

V: vertebrae

m: male

f: female

nSr: natural (stable) Sr

eqv. mg KCl: equivalents mg KCl: activity as from 1 mg KCl (~ 0.88 dpm)

S.D.: standard deviation: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{(n-1)}}$

S.E.: standard error: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{n(n-1)}}$

U.C.L.: upper control level

L.C.L.: lower control level

S.S.D.: sum of squares of deviation: $\Sigma(\bar{x}-x_i)^2$

f: degrees of freedom

s^2: variance

v^2: ratio between the variance in question and the residual variance

P: probability fractile of the distribution in question

n: coefficient of variation, relative standard deviation

ANOVA: analysis of variance

A: relative standard deviation 20-33%

B: relative standard deviation >33%, such results are not considered significantly different from zero activity

B.D.L.: below detection limit

In the significance test the following symbols were used:

* : probably significant (P > 95%)

** : significant (P > 99%)

***: highly significant (P > 99.9%)

1. INTRODUCTION

1.1.

The fallout programme for the Faroes, which was initiated in 1962[1)] in close co-operation with the National Health Service and the chief physician of the Faroes, was continued in 1982. Samples of human bone were obtained in 1982 from Dronning Alexandrine's Hospital in Thorshavn.

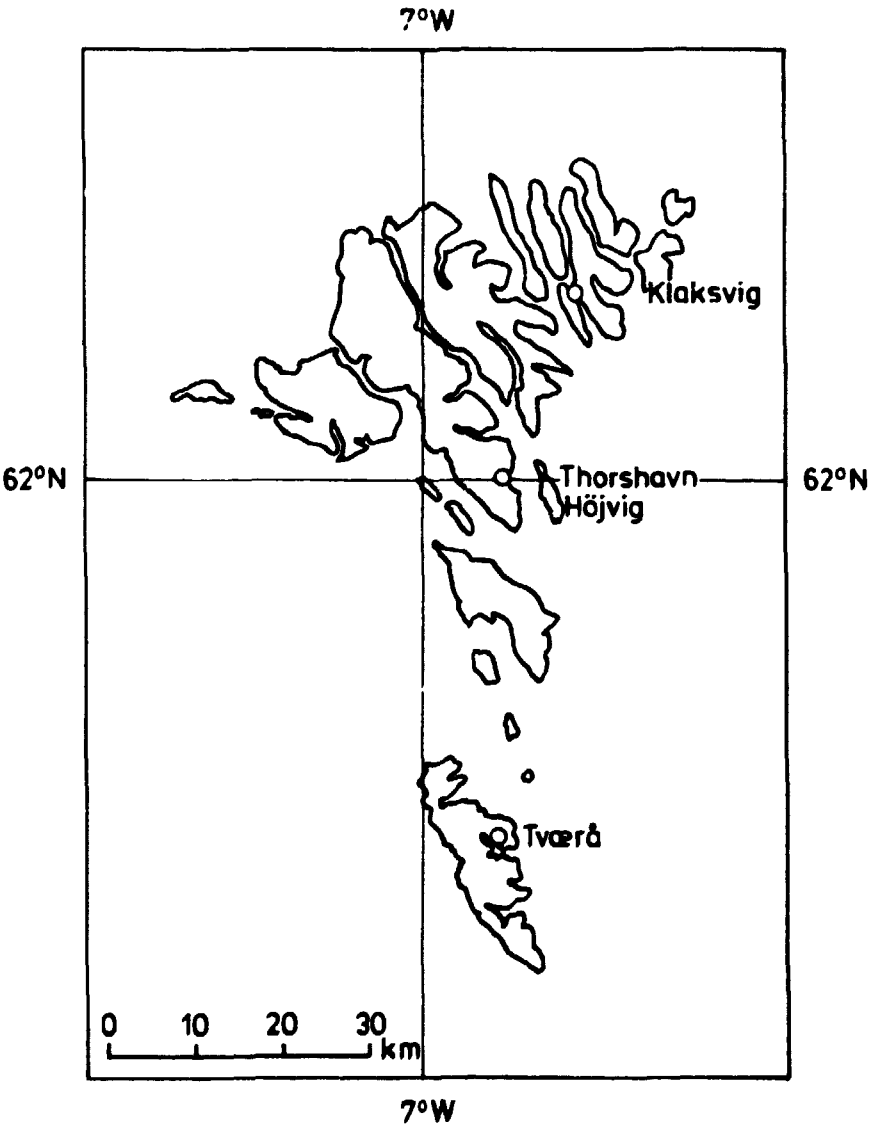

Fig. 1. The Faroese Islands.

1.2.

The present report will not repeat information concerning sample collection and analysis already given in Risø Reports Nos. 64, 86, 108, 131, 155, 181, 202, 221, 246, 266, 292, 306, 324, 346, 361, 387, 404, 422, 448 and 470[1].

1.3.

The estimated mean diet of the Faroese as used in this report is still based on the estimate given by the late Professor E. Hoff.Jørgensen, Ph.D., in 1962.

1.4.

The present investigation was carried out together with corresponding examinations of fallout levels in Denmark and Greenland, described in Risø Reports Nos. 487[2] and 489[3], respectively.

2. RESULTS AND DISCUSSION

2.1. Strontium-90 in precipitation

Table 2.1 shows the ^{90}Sr content in precipitation collected at Højvig (near Thorshavn) and Klaksvig in 1982. The amount of fallout at Højvig was a factor of 1.6 greater than that found at Klaksvig.

The ^{90}Sr fallout in 1982 was approximately 0.25 times of the 1981 levels in the Faroes. In Denmark the 1982 levels were 0.15 times the 1981 levels[2].

Table 2.1.1. Strontium-90 in precipitation in the Faroes in 1982 (sampling area = 0.02 m^2)

	Höjvig		Klaksvig	
	Bq m^{-3}	Bq m^{-2}	Bq m^{-3}	Bq m^{-2}
Jan-Feb	5.6	1.92	2.8	1.24
March-April	5.3	1.13	4.8	1.24
May-June	6.3	0.78	4.0	1.24
July-Aug	3.8	1.26	4.2 A	0.22 A
Sept-Oct	4.1	1.43	1.5 A	0.42 A
Nov-Dec	3.6	1.23	0.87	0.43
1982	4.6	Σ 7.8 Σ_m 1.700	2.6	Σ 4.8 Σ_m 1.838
1982	0.123 pCi l^{-1}	Σ 0.21 mCi km^{-2}	0.070 pCi l^{-1}	Σ 0.129 mCi km^{-2}

Table 2.1.2. Fallout rates and accumulated fallout (Bq ^{90}Sr m^{-2}) in the Faroes 1950-1982

	Höjvig		Klaksvig	
	d_i	$A_{i(29)}$	d_i	$A_{i(29)}$
1950	1.08	1.06	2.15	2.10
1951	5.21	6.12	10.34	12.14
1952	10.21	15.94	20.27	31.64
1953	25.78	40.74	51.18	80.87
1954	98.02	135.48	194.58	268.94
1955	128.96	258.20	256.00	512.54
1956	159.90	408.22	317.41	810.34
1957	159.90	554.70	317.41	1101.12
1958	221.82	758.18	440.34	1505.05
1959	314.64	1047.48	624.58	2079.33
1960	58.78	1080.14	116.69	2144.16
1961	76.36	1129.19	151.59	2241.52
1962	383.01	1476.48	760.31	2930.93
1963	913.00	2333.05	1503.00	4329.21
1964	544.00	2809.10	1363.00	5557.77
1965	181.00	2919.46	436.00	5852.21
1966	112.00	2959.88	289.00	5996.17
1967	94.70	2982.44	182.00	6032.25
1968	44.00	2954.96	55.50	5943.97
1969	41.10	2925.30	65.10	5867.15
1970	53.60	2908.54	141.00	5866.25
1971	101.00	2938.46	156.00	5880.02
1972	34.40	2902.65	55.10	5794.94
1973	24.20	2857.73	26.50	5683.95
1974	33.80	2823.23	58.80	5607.12
1975	34.40	2790.14	47.80	5521.36
1976	8.88	2732.91	21.60	5412.05
1977	27.40	2695.12	34.40	5317.81
1978	37.30	2667.89	47.60	5238.69
1979	13.90	2618.45	22.20	5136.64
1980	11.70	2568.03	12.60	5027.63
1981	22.50	2529.35	26.70	4934.95
1982	7.75	2477.18	4.79	4823.08

1950-1961: are estimated values based upon HASL data (HASL Appendix 291, 1975) considering that the mean ratio between ^{90}Sr fallout in Denmark and New York was 0.7 in the period 1962-1974 and that the mean ratios between ^{90}Sr fallout in Höjvig and Denmark and between Klaksvig and Denmark are 1.39 and 2.76, respectively[5].

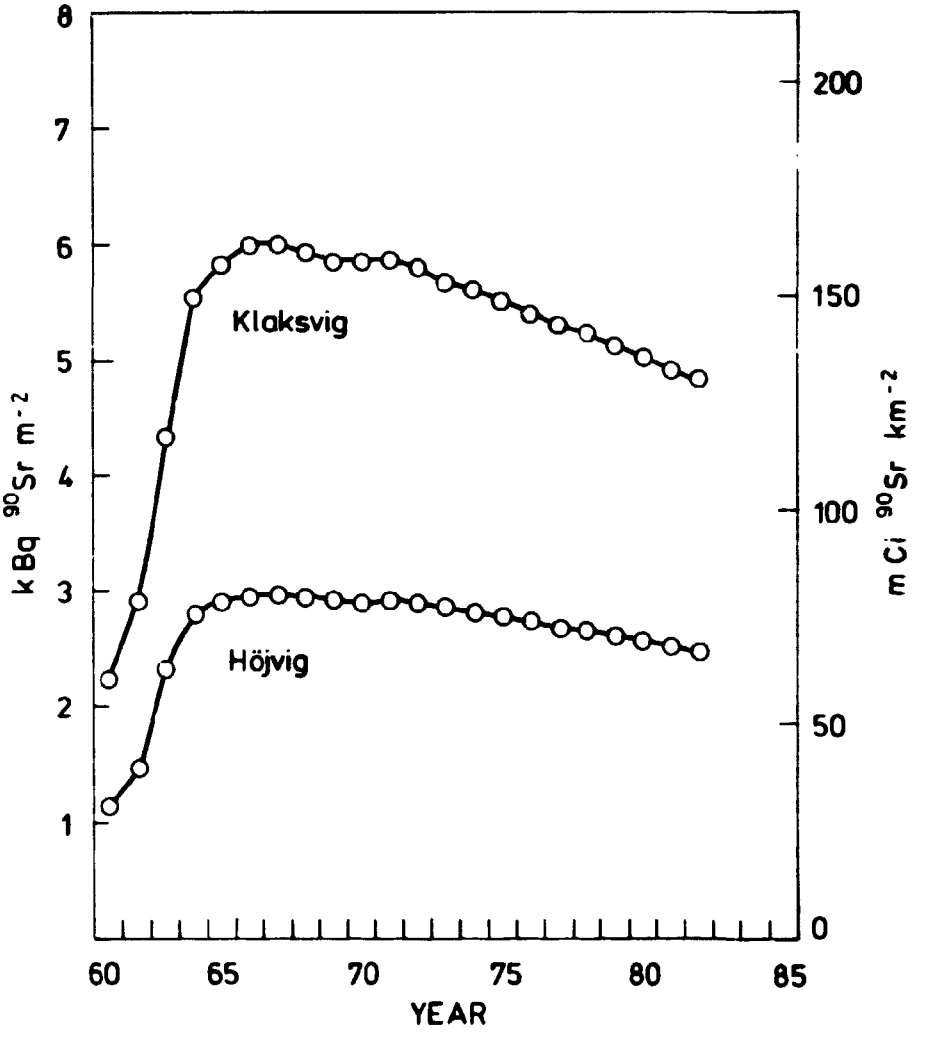

Fig. 2.1. Accumulated ^{90}Sr at Klaksvig and Højvig calculated from precipitation measurements since 1962. The accumulated fallout by 1962 was estimated from Table 2.1.2.

2.2. Strontium-90 and Cesium-137 in grass

Grass samples were collected near Thorshavn in 1982. Table 2.2 shows the results. The 1982 ^{137}Cs mean level in grass was 0.74 times the 1981 level. As compared with Danish grass in 1982[2] we found the ^{90}Sr level in the Faroese grass to be higher by a factor of approximately 12 in the summer months.

Table 2.2. Strontium-90 and Cesium-137 in grass from Thorshavn 1982

Month	Bq ^{90}Sr kg^{-1}	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs kg^{-1}	Bq ^{137}Cs (kg K)$^{-1}$	^{137}Cs/^{90}Sr
June	3.5	6200	15.4	3700	4.4
September	1.42	3000	4.1	1020	2.9

2.3. Strontium-90 and Cesium-137 in milk

As in previous years[1], weekly samples of fresh milk were obtained from Thorshavn, Klaksvig, and Tværå. Strontium-90 and ^{137}Cs were determined in bulked monthly samples.

Table 2.3.1 shows the results and Tables 2.3.2, 2.3.3 and 2.3.4 the analysis of variance of the Bq ^{90}Sr (kg Ca)$^{-1}$, Bq ^{137}Cs (kg K)$^{-1}$, and Bq ^{137}Cs m^{-3} figures respectively. As also observed in previous years, the variation between locations was significant for ^{137}Cs as well as for ^{90}Sr. The highest levels were found in the milk from Tværå, and the lowest in Thorshavn milk.

Figure 2.3.1 shows the quarterly Bq ^{90}Sr (kg Ca)$^{-1}$ values and Fig. 2.3.2 the quarterly Bq ^{137}Cs m^{-3} levels since 1962. The annual mean values for 1982 were 220 Bq ^{90}Sr (kg Ca)$^{-1}$ (5.9 S.U.) and 4400 Bq ^{137}Cs m^{-3} (119 pCi ^{137}Cs l^{-1}), i.e. the ^{90}Sr levels in 1982 were 88% of the 1981 concentration, while the ^{137}Cs levels were approximately 86% of the 1981 mean levels. In Danish milk the ^{90}Sr concentration did not change from 1981 to 1982, but the ^{137}Cs 1982 level was 77% of the 1981 content.

The annual mean values of the ratio: Bq ^{137}Cs (kg K)$^{-1}$/Bq ^{90}Sr (kg Ca)$^{-1}$ in Faroese milk are shown in Fig. 2.3.3. The mean ratio in 1982 for the three locations was 11.9±1.0 (1 S.E.) during the grazing period (May-October), and in the winter time it was 12.8±0.9. These ratios were similar to those observed in 1981.

Figure 2.3.4 shows a comparison between the ^{90}Sr and ^{137}Cs levels in Faroese- and Danish-produced milk. It is evident that indirect contamination plays an important role for the ^{137}Cs levels in the Faroes, because the ratio between ^{137}Cs in Faroese and Danish milk increases when the fallout rate decreases. The ratios between the ^{90}Sr levels in Faroese and Danish milk have shown a slight tendency to decrease through the years.

Table 2.3.1. Strontium-90 and Cesium-137 in milk from the Faroes in 1982

Month	Thorshavn			Klaksvig			Tvarå			Mean		
	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs m^{-3}	Bq ^{137}Cs (kg K)$^{-1}$	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs m^{-3}	Bq ^{137}Cs (kg K)$^{-1}$	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs m^{-3}	Bq ^{137}Cs (kg K)$^{-1}$	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs m^{-3}	Bq ^{137}Cs (kg K)$^{-1}$
Jan	171	2000	1290	220	6200	3600	280	4500	2400	220	4200	2400
Feb	150	1340	870	205	4900	3100	204	4500	2800	186	3600	2300
March	157	1630	1060	(210)	4700	2800	250	4300	2500	200	3500	2100
April	155	1270	960	210	4600	2800	208	5100	3100	190	3700	2300
May	176	2100	1280	220	4600	2900	202	4700	2700	200	3800	2300
June	250	2700	1550	230	4100	2500	220	3400	2000	230	3400	2000
July	240	3700	2400	280	4100	2600	380	7600	4300	300	5100	3100
Aug	220	2900	1910	270	6400	4000	320	9800	6900	270	6400	4300
Sept	210	2300	1300	230	4400	2700	240	8400	5000	230	5000	3000
Oct	134	2100	1190	171	4500	2600	250	5000	2900	184	3900	2200
Nov	141	2100	1340	183	6900	3900	202	4900	2900	175	4600	2700
Dec	(166)	(3000)	(1640)	204	7100	3700	(230)	(7700)	(4000)	200	5900	3100
Mean	181	2300	1400	220	5200	3100	250	5800	3500	220	4400	2700

The figures in brackets were calculated from the anova.

Table 2.3.2. Analysis of variance of ln Bq ^{90}Sr (kg Ca)$^{-1}$ in Faroese milk in 1982 (from Table 2.3.1)

Variation	SSD	f	s^2	v^2	P
Between months	0.841	11	0.076	5.236	> 99.9%
Between locations	0.603	2	0.301	20.639	> 99.95%
Remainder	0.277	19	0.015		

Table 2.3.3. Analysis of variance of ln Bq ^{137}Cs (kg K)$^{-1}$ in Faroese milk in 1982 (from Table 2.3.1)

Variation	SSD	f	s^2	v^2	P
Between months	1.326	11	0.121	2.173	-
Between locations	5.600	2	2.800	50.497	> 99.95%
Remainder	1.109	20	0.055		

Table 2.3.4. Analysis of variance of ln Bq ^{137}Cs m^{-3} in Faroese milk in 1982 (from Table 2.3.1)

Variation	SSD	f	s^2	v^2	P
Between months	1.274	11	0.116	1.900	-
Between locations	6.304	2	3.152	51.709	> 99.95%
Remainder	1.219	20	0.061		

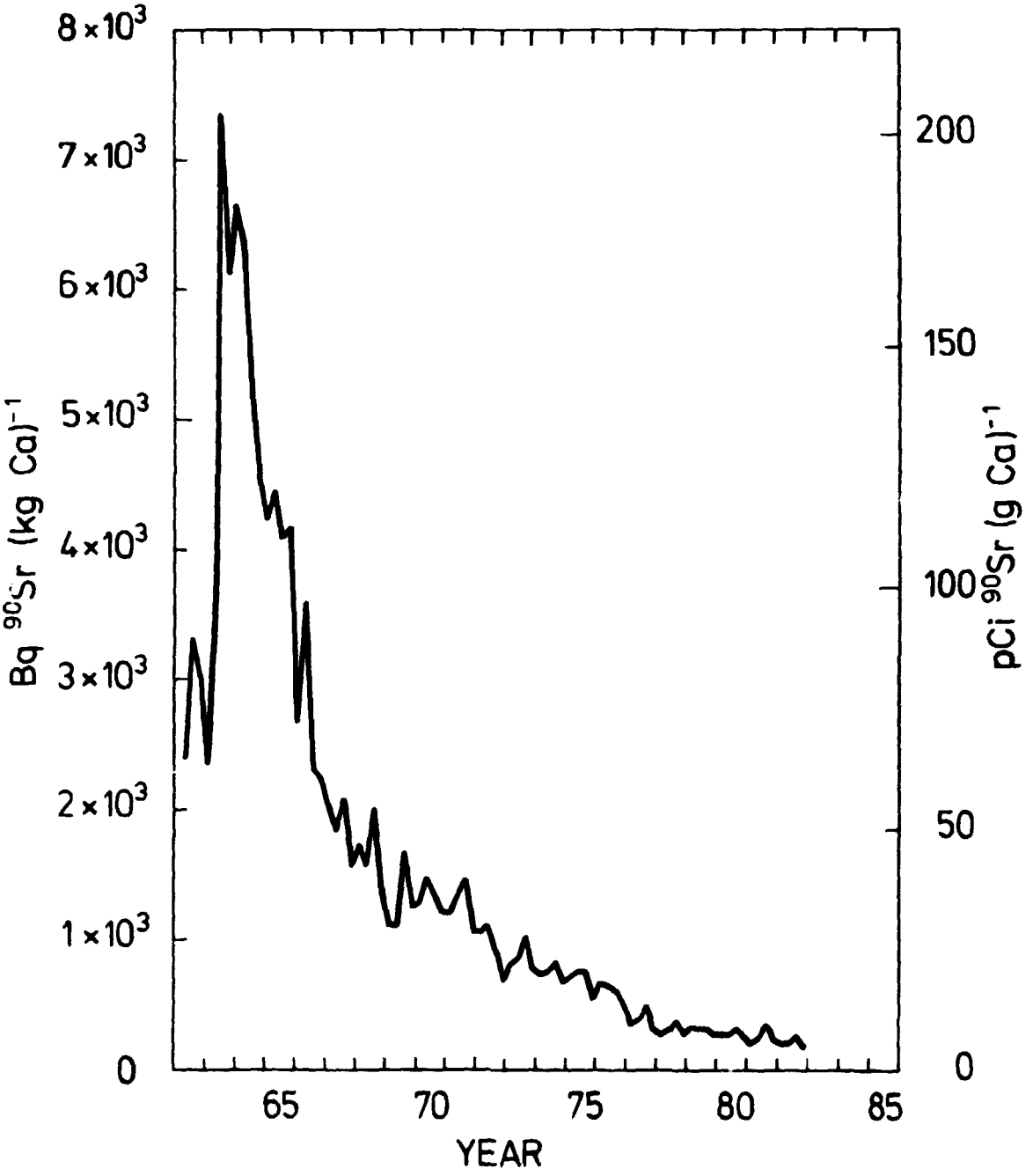

Fig. 2.3.1. Strontium in Faroese milk, 1962-1982.

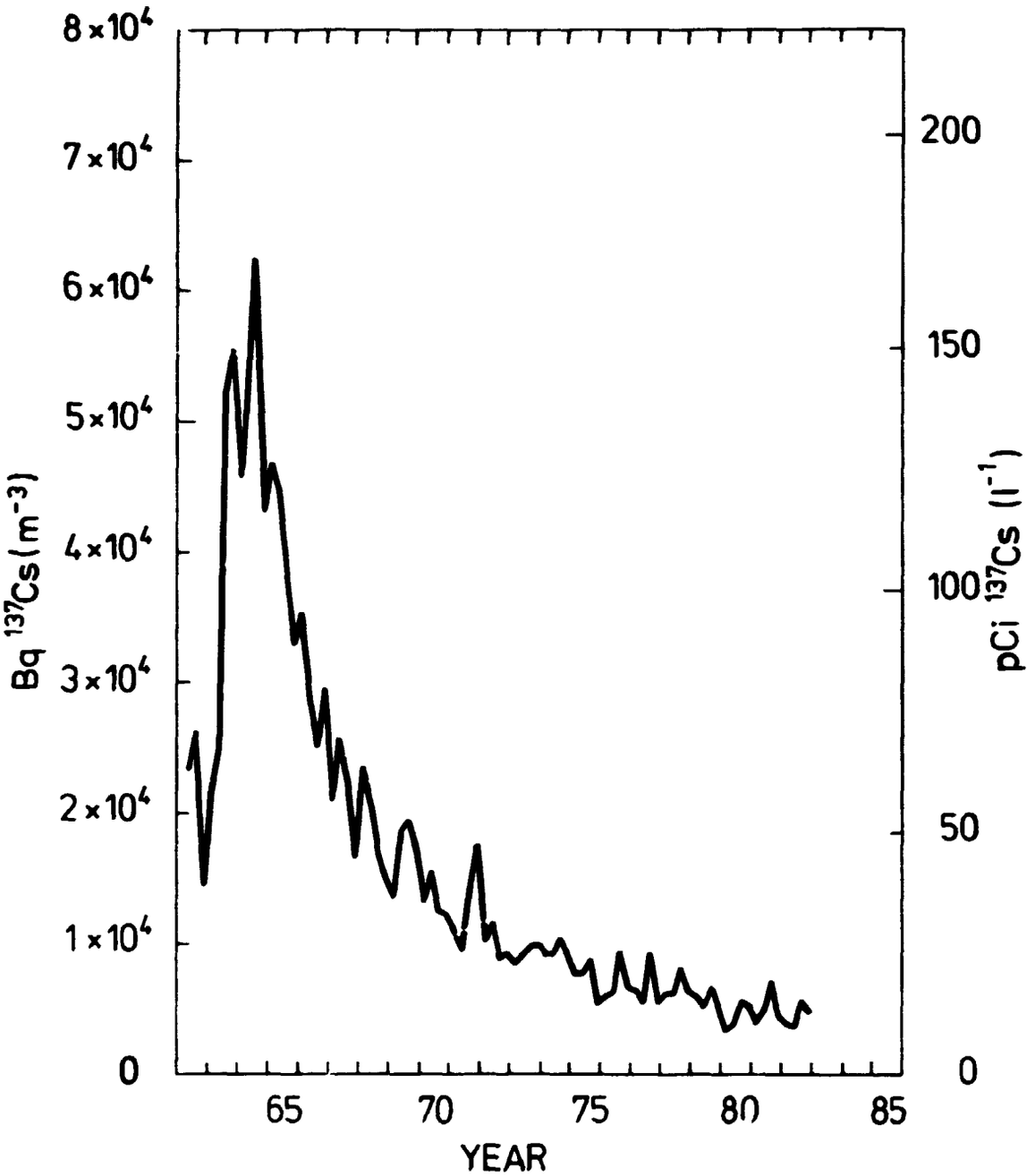

Fig. 2.3.2. Cesium-137 in Faroese milk, 1962-1982.

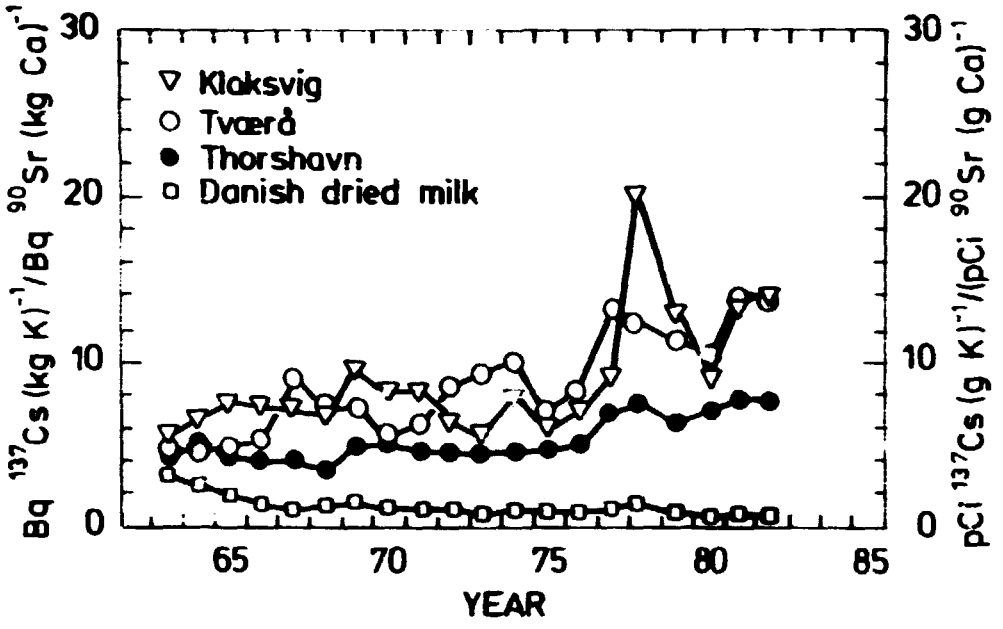

Fig. 2.3.3. $\frac{\text{N.U.}}{\text{S.U.}}$ ratios in Faroese and Danish milk, 1963-1982.

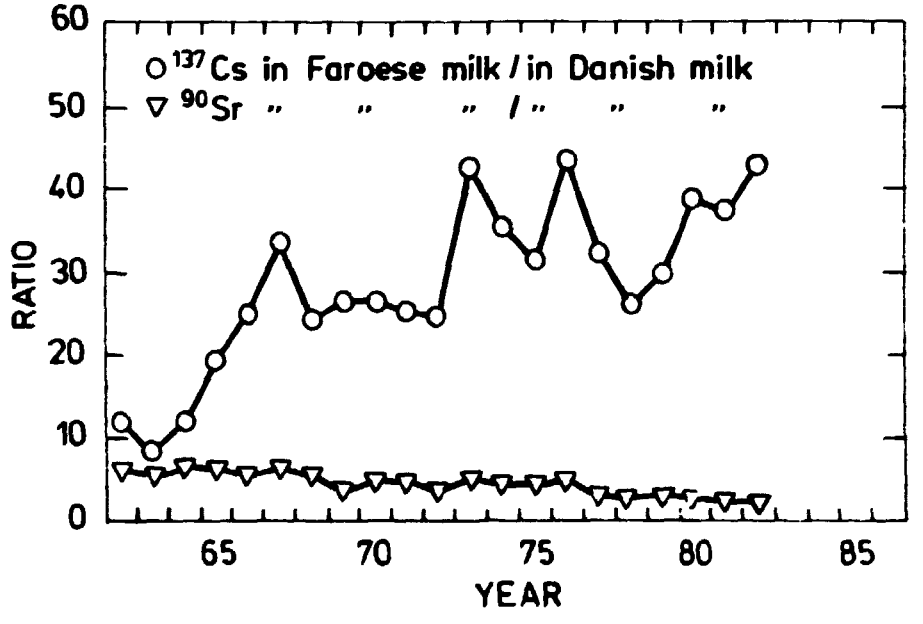

Fig. 2.3.4. A comparison between Faroese and Danish milk levels, 1962-1982.

2.4. Strontium-90 and Cesium-137 in terrestrial animals

No samples were obtained in 1982 from the Faroes.

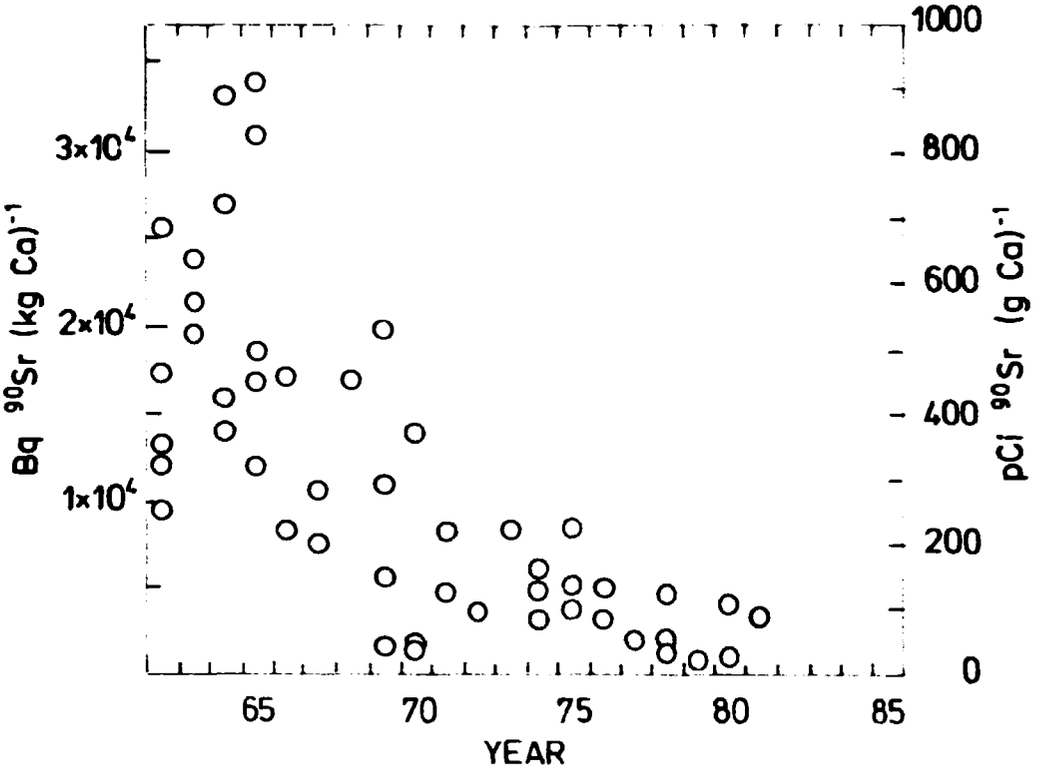

Fig. 2.4.1. Strontium-90 (Bq (kg Ca)$^{-1}$) in lamb bone collected in the Faroes, 1962-1982.

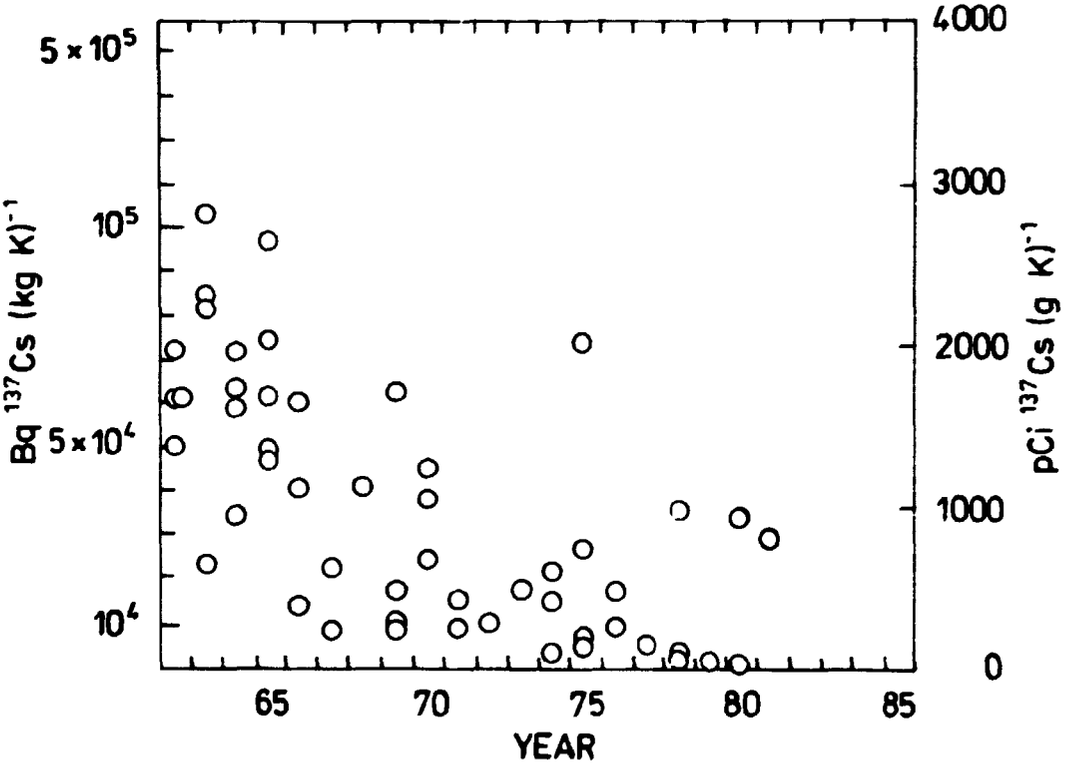

Fig. 2.4.2. Cesium-137 (Bq (kg K)$^{-1}$) in lamb meat collected in the Faroes, 1962-1982.

2.5. Strontium-90 and Cesium-137 in sea animals

Table 2.5.1 shows the ^{137}Cs levels in fish collected in 1982 in the Faroes. The mean levels in Gadus aeglefinus and Gadus callarias were 0.26 Bq ^{137}Cs kg^{-1} and 0.018 Bq ^{90}Sr kg^{-1}.

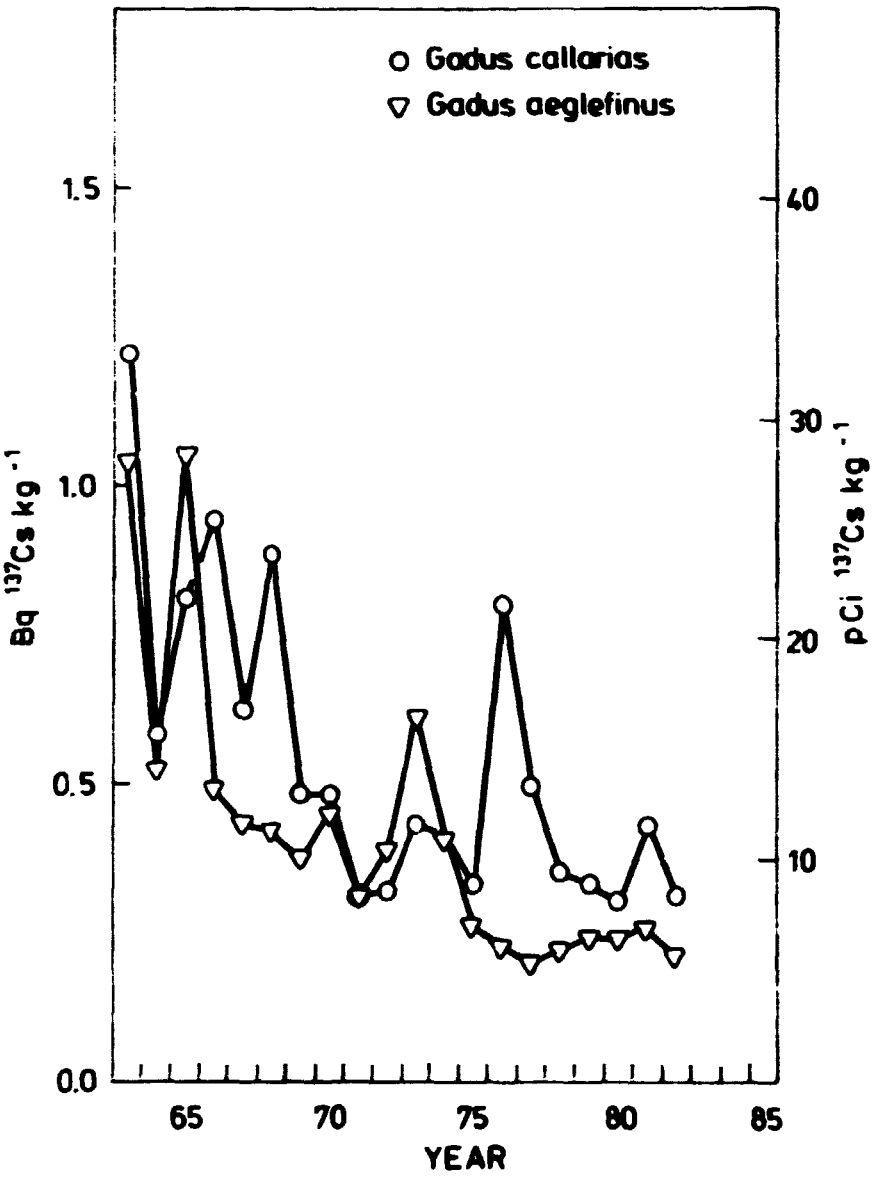

Fig. 2.5.1. Cesium-137 levels in meat of cod (Gadus callarias) and Haddock (Gadus aeglefinus) collected in the Faroes, 1962-1992.

Table 2.5.1. Strontium-90 and Cesium-137 in fish flesh from the Faroes in 1982

Sampling month	Species	Sample type	Bq ^{90}Sr kg^{-1}	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs kg^{-1}	Bq ^{137}Cs (kg K)$^{-1}$
March	Gadus callarias	Cod flesh	0.0086	69	0.33	113
June	- " -	- " -	0.0182	159	0.32	111
Dec	- " -	- " -	0.0066 A	75 A	0.28	76
March	Gadus aeglefinus	Haddock flesh	0.0132	120	0.25	67
June	- " -	- " -	0.0023	65	0.171	56
Sept	Gadus I	Cod or	0.040	220	0.25	72
-	" II	Haddock flesh	0.0153	160	0.26	70

2.6. Strontium-90 in drinking water

Drinking-water samples were collected as previously but the samples were combined before the analysis as shown in Table 2.6.1. As in previous years, drinking water from Thorshavn contained more ^{90}Sr than that from Klaksvig and Tværå (cf. the explanation in Risø Report No. 181[1]). The mean level in 1982 was 5.5 Bq ^{90}Sr m^{-3} (0.15 pCi l^{-1}), i.e. a little higher than in 1981.

Table 2.6.1. Strontium-90 in drinking water from the Faroes in 1982 (Unit: Bq m^{-3})

	Thorshavn	Klaksvig	Tværå
Jan-June	10.8	2.0	5.0
July-Dec	8.5	1.31	5.5
1982	9.6	1.67	5.3

Table 2.6.2. Tritium in drinking water from the Faroes in 1982. (Unit: kBq m^{-3})

	Thorshavn	Klaksvig	Tværå
Jan-June	1.8±0.0	2.4±0.4	2.0±0.2
July-Dec	2.0±0.2	1.8±0.2	1.5±0.2
1982	1.9	2.1	1.8

The error term is 1 S.E. of the mean of double determinations.

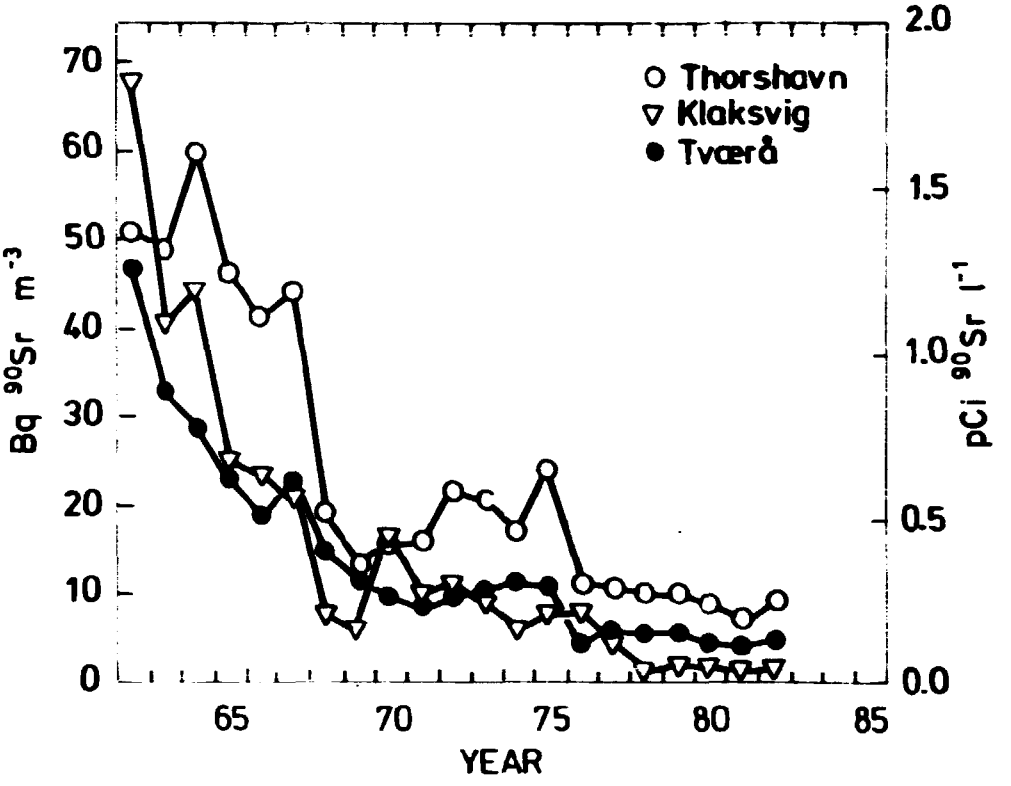

Fig. 2.6.1. Strontium-90 in drinking water from the Faroes, 1962-1982.

Figure 2.6.1 shows the annual mean levels of ^{90}Sr in drinking water from the three locations since 1962.

The tritium concentrations in Faroese drinking water (Table 2.6.2) did not follow the ^{90}Sr levels. The mean tritium level in 1982 was 1.9±0.15 (1 S.D.) kBq m^{-3}, this is approximately 1/2 of the 1981 level. The decrease shows that tritium in Faroese drinking water is related to the concentrations of fallout in recent precipitation.

2.7. Strontium-90 and Cesium-137 in miscellaneous samples

No samples.

2.7.2 Sea water

Surface sea water was collected near Thorshavn on two occasions in 1982. The ^{90}Sr mean level was 3.0 Bq ^{90}Sr m^{-3} and 3.3 Bq ^{137}Cs m^{-3}.

Figure 2.7.2 shows the ^{90}Sr levels since 1962.

The $^{137}Cs/^{90}Sr$ ratio was 1.12±0.33 (1 S.D.), i.e. probably less than expected for fallout in ocean water.

The mean tritium concentration (±1 S.D.) was 2.1±1.06 kBq ^{3}H m^{-3} in the waters around the Faroes (cf. Table 2.7.2.2). The tritium concentrations did not show any correlation with the ^{137}Cs contents of the sea water.

Table 2.7.2.1. Strontium-90 and Cesium-137 in surface sea water from the Faroes in 1982

Sampling month	Bq ^{90}Sr m^{-3}	Bq ^{137}Cs m^{-3}	Salinity o/oo
March	2.6	3.5	34.9
September	3.5	3.1	35.0
1982	3.0	3.3	35.0

Table 2.7.2.2. Strontium-90, Cesium-137, Cesium-134 and Tritium in sea water collected between 0 and 10°W longitude in 1982

	Position N	Position W	Date	Temp. °C	^{90}Sr Bq m^{-3}	^{137}Cs Bq m^{-3}	^{134}Cs Bq m^{-3}	^{3}H kBq m^{-3}	Salinity o/oo
Fylla	59°36'5	1°18'0	18/2		17.5	100	3.8	1.8±0.7	35.1
"	60°14'6	3°28'6	19/2		3.1	7.2	B.D.L.	1.1±0.7	35.6
"	60°47'7	5°37'5	19/2		2.2	4.1	"	3.5±0.2	35.4
"	61°13'1	7°26'6	19/2		2.3	3.7	"	3.2±0.6	35.4
Nella Dan	61°31'8	0°39'2	2/8	13		10.8	0.4 A	3.7	35.3
" "	64°38'5	7°28'8	3/8	9		3.1	B.D.L.	1.5	34.7
" "	64°31'0	8°04'2	26/8	7.5	2.5	4.0	"	1.1±0.4	34.6
" "	63°41'0	6°13'1	27/8	9	2.3	3.4	"	1.0±0.5	34.8
" "	62°38'3	3°59'8	27/8	10		3.3	"	1.4	35.1
" "	61°33'6	1°59'8	27/8	12	2.1	3.5	"		34.9
" "	60°39'4	0°05'0	27/8	12		26	Spiked	2.6	35.2

The error term is ± S.E. of the mean of double determinations.

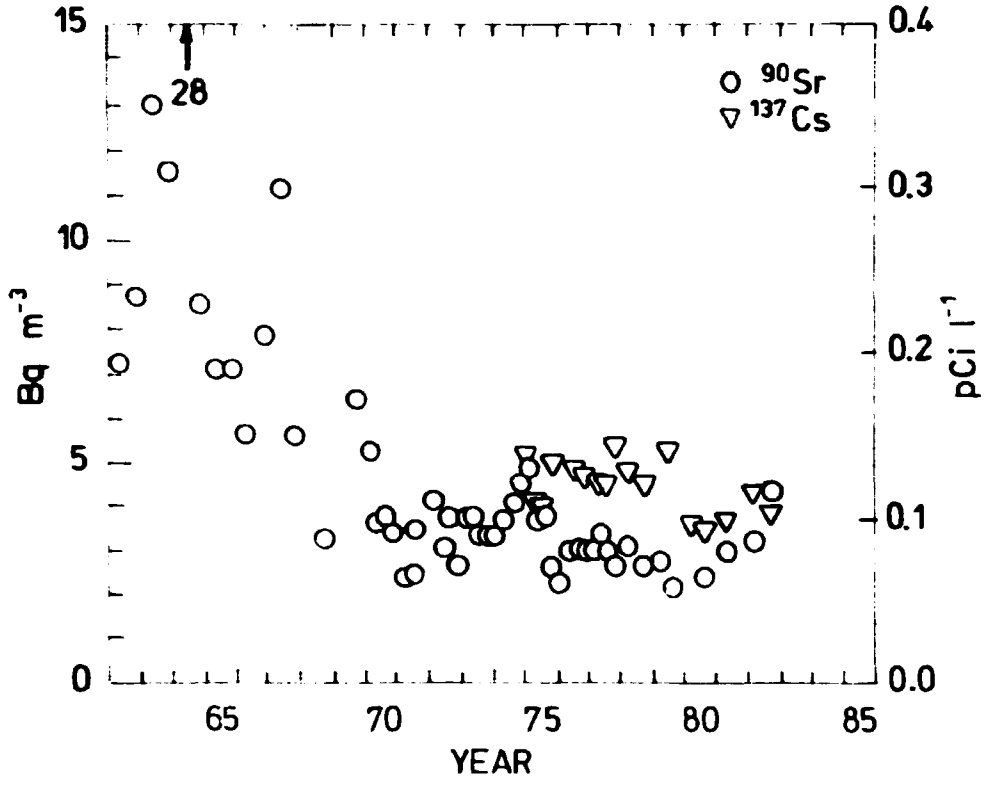

Fig. 2.7.2.1. Strontium-90 and Cesium-137 in Faroese sea water, 1962-1982.

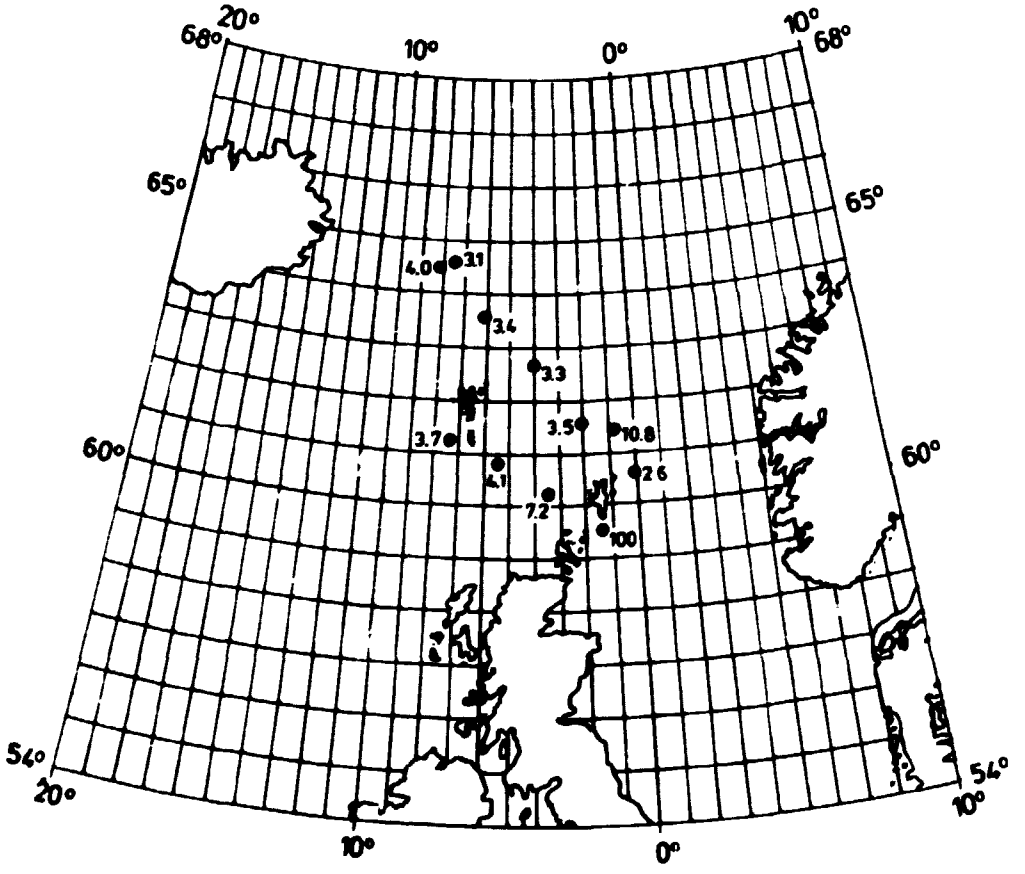

Fig. 2.7.2.2. Cesium-137 in sea water collected between 0 and 10° W longitude in 1982.

2.7.3. Sea plants

One sample of Brown algae was analysed in 1982. It contained 1.14 Bq ^{90}Sr kg^{-1} ash (20 Bq ^{90}Sr (kg Ca)$^{-1}$) and 0.66 Bq ^{137}Cs kg^{-1} dry weight or 2.7 Bq kg^{-1} ash (13 Bq ^{137}Cs (kg K)$^{-1}$).

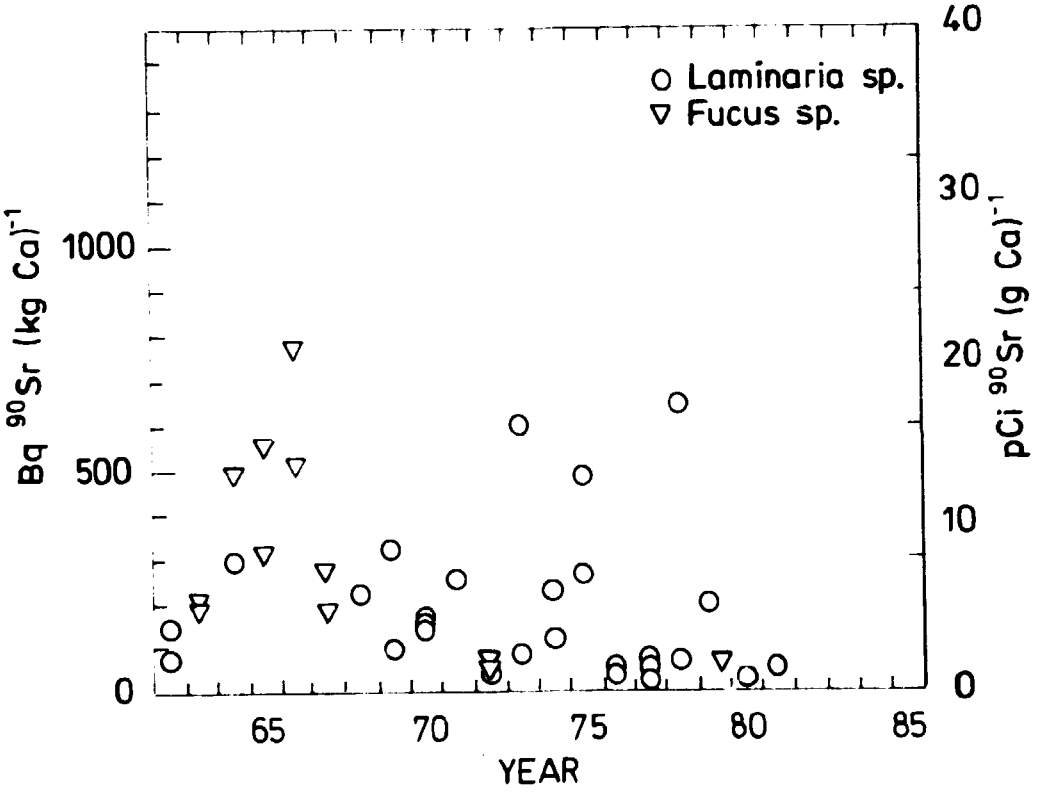

Fig. 2.7.3. Strontium-90 (Bq (kg Ca)$^{-1}$) in sea plants collected at Thorshavn, 1962-1982.

2.7.4. Vegetables

One sample of potatoes was analysed in 1982. It contained 0.37 Bq ^{90}Sr kg^{-1} (9700 Bq ^{90}Sr (kg Ca)$^{-1}$) and 4.4 Bq ^{137}Cs kg^{-1} (1330 Bq ^{137}Cs (kg K)$^{-1}$). Both levels were higher than those observed in 1981.

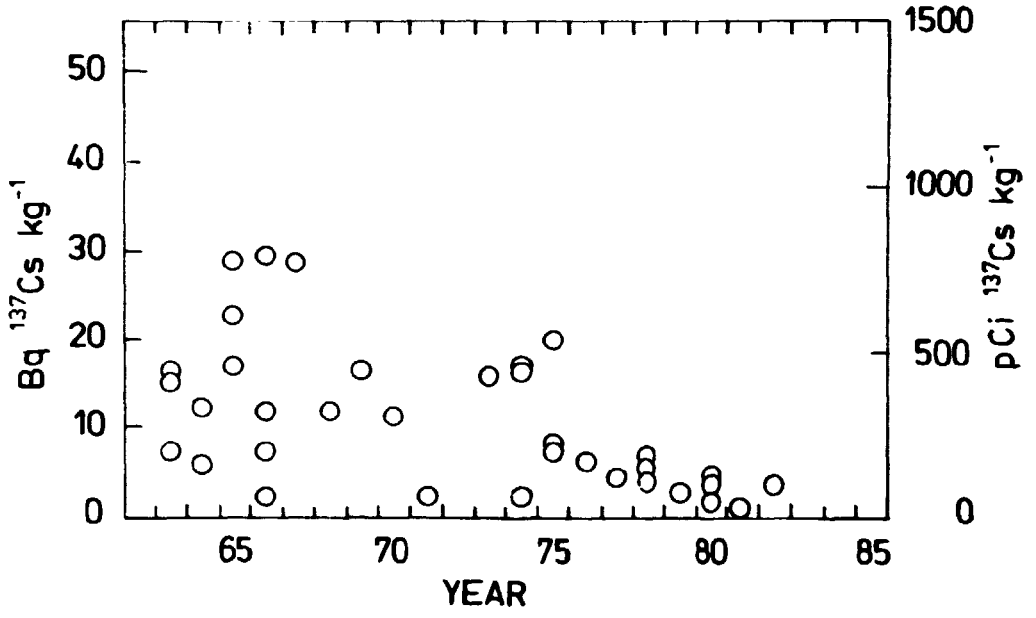

Fig. 2.7.4.1. Cesium-137 in Faroese potatoes, 1962-1982.

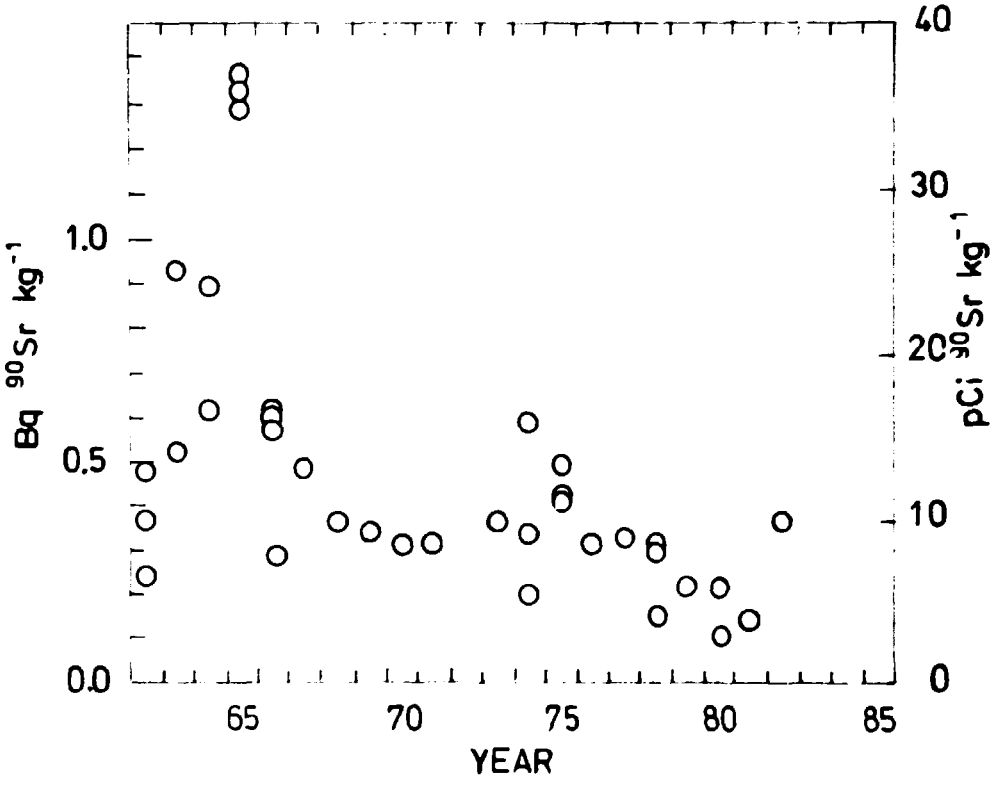

Fig. 2.7.4.2. Strontium-90 in Faroese potatoes, 1962-1982.

2.7.5. Bread

Rye bread and white bread were collected at Thorshavn in June. The levels in white bread were 0.24 Bq ^{90}Sr kg^{-1} and 0.23 Bq ^{137}Cs kg^{-1}. The rye bread collected in 1982 contained 0.35 Bq ^{90}Sr kg^{-1} and 0.43 Bq ^{137}Cs kg^{-1}, i.e. the bread levels were higher than the 1980 levels. The Bq ^{90}Sr (kg Ca)$^{-1}$ figures

were lower than those from last year, because the Ca contents of the Faroese bread samples were higher than usually; the Ca levels were in 1982 similar to those found in Danish bread.

The ^{137}Cs and ^{90}Sr (kg^{-1}) levels in Faroese bread were generally lower than the corresponding Danish[2].

Table 2.7.5. Strontium-90 and Cesium-137 in Faroese bread in June 1982

Sort	Bq ^{90}Sr kg^{-1}	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs kg^{-1}	Bq ^{137}Cs (kg K)$^{-1}$
White bread	0.24	120	0.23	148
Rye bread	0.35	137	0.45	195

2.7.6. Eggs

Eggs were collected from Thorshavn in June 1982. The levels of hens eggs were 0.037 Bq ^{90}Sr kg^{-1} (92 Bq (kg Ca)$^{-1}$ and 0.18 Bq ^{137}Cs kg^{-1}.

2.8. Humans

2.8.1. Strontium-90 in human bone

In 1982 four human bone samples representing 4 individuals from Dronning Alexandrine's Hospital in Thorshavn were analysed. Table 2.8.1 shows the results.

The mean content of femur samples was 44 Bq ^{90}Sr (kg Ca)$^{-1}$ (1.2 pCi ^{90}Sr (g Ca)$^{-1}$).

Table 2.8.1. Strontium-90 in human bone collected in the Faroes in 1982

Age	Bone type		Sex	Bq ^{90}Sr (kg Ca)$^{-1}$	S.U.
82 years	Femur	Amputation	F	28	0.76
81 years	Femur	- " -	F	63	1.70
96 years	Femur	- " -	F	42	1.15
70 years	Vertebrae		F	117	3.2

Compared to Danish vertebrae in 1982[2] th Faroese sample of vertebrae contained approximately three times as much ^{90}Sr.

3. ESTIMATE OF THE MEAN CONTENTS OF ^{90}Sr AND ^{137}Cs IN THE HUMAN DIET

3.1. Annual quantities

The annual quantities are still based on the estimate made by the late Professor E. Hoff-Jørgensen, Ph.D., in 1962[1] assuming a daily per caput intake of approximately 3000 calories (12.6 MJ).

3.2. Milk and cream

75% of the milk consumed in the Faroes is assumed to be of local origin, and 25% comes from Denmark. Hence the ^{90}Sr content in milk consumed in the Faroes in 1982 was $1.2 \cdot (0.75 \cdot 0.22 + 0.25 \cdot 0.102) = 0.229$ Bq ^{90}Sr kg^{-1}, and the ^{137}Cs content was $0.75 \cdot 4.4 + 0.25 \cdot 0.105 = 3.33$ Bq ^{137}Cs kg^{-1} (cf. 2.3 and Ref. 2). 1 kg milk contains 1.2 g Ca.

3.3. Cheese

Nearly all cheese consumed in the Faroes is of Danish origin, and the Danish figures from ref. 2 were used: 0.87 Bq ^{90}Sr kg^{-1} and 0.076 Bq ^{137}Cs kg^{-1}.

3.4. Grain products

As most grain products are imported from Denmark, the Danish figures for 1982[2] were used in the calculation of the Faroese levels. The mean daily consumption of grain products in the Faroes is, as in Denmark, 80 g rye flour, 120 g wheat flour, and 20 g grits. Hence the mean concentration of ^{90}Sr in grain products consumed in the Faroes in 1982 is 0.47 Bq ^{90}Sr kg^{-1} and 0.57 Bq ^{137}Cs kg^{-1}.

3.5. Potatoes

All potatoes consumed in the Faroes are assumed to be of local origin. The values from 2.7.4 were used, i.e. 0.37 Bq ^{90}Sr kg^{-1} and 4.4 Bq ^{137}Cs kg^{-1}.

3.6. Other vegetables and fruit

As the amount of vegetables and fruit grown in the Faroes is limited, the Danish figures from 1982[2] were used. Thus the mean contents in vegetables other than potatoes were 0.32 Bq ^{90}Sr kg^{-1} and 0.053 Bq ^{137}Cs kg^{-1}, and the mean contents in fruit were 0.054 Bq ^{90}Sr kg^{-1} and 0.038 Bq ^{137}Cs kg^{-1}.

3.7. Meat and eggs

Meat and egg consumption in the Faroes is estimated to consist of 50% locally produced mutton (or lamb), 25% local whale meat, and 25% sea birds and eggs.

No samples of mutton was obtained in 1982. Hence we use the mean of the samples obtained in 1979-1981, i.e. 0.20 Bq ^{90}Sr kg^{-1} and 49 Bq ^{137}Cs kg^{-1}.[1]) Whale meat from 1980 contained 0.04 Bq ^{90}Sr kg^{-1} and 0.19 Bq ^{137}Cs kg^{-1}, sea birds from 1979 and eggs from 1982 (cf. 2.7.6): 0.007 Bq ^{90}Sr kg^{-1} and 0.037 Bq ^{90}Sr kg^{-1}, and 0.27 and 0.18 Bq ^{137}Cs kg^{-1} respectively. Hence we estimate the mean content of ^{90}Sr in meat and eggs consumed in 1982 to be

$$0.50 \cdot 0.20 + 0.25 \cdot 0.04 + 0.25 \cdot \left(\frac{0.007+0.037}{2}\right) = 0.133 \text{ Bq } ^{90}Sr \text{ } kg^{-1}$$

and the ^{137}Cs content to be

$$0.50 \cdot 49 + 0.25 \cdot 0.19 + 0.25 \cdot \left(\frac{0.27+0.18}{2}\right) = 24.6 \text{ Bq } ^{137}Cs \text{ } kg^{-1}.$$

3.8. Fish

All fish consumed in the Faroes is of local origin, and the mean contents in fish, obtained from subsection 2.5, were 0.018 Bq ^{90}Sr kg^{-1} and 0.26 Bq ^{137}Cs kg^{-1}.

3.9. Coffee and tea

The Danish figures for 1982[2] were used, i.e. 0.87 Bq ^{90}Sr kg^{-1} and 2.53 Bq ^{137}Cs kg^{-1}.

3.10. Drinking water

The mean value found in Table 2.6.1 was used, i.e. 0.0055 Bq ^{90}Sr kg^{-1}. The ^{137}Cs content was estimated to be approximately one fourth (the ratio found in New York tap water in 1964[4]) of the ^{90}Sr content, i.e. 0.0014 Bq ^{137}Cs kg^{-1}.

Tables 3.1 and 3.2 show the diet estimates of ^{90}Sr and ^{137}Cs respectively.

Table 3.1. Estimate of the mean content of ^{90}Sr in the human diet in the Faroe Islands in 1982

Type of food	Annual quantity in kg	Bq ^{90}Sr per kg	Total Bq ^{90}Sr	Percentage of total Bq ^{90}Sr in food
Milk and cream	146	0.229	33.43	24.9
Cheese	7.3	0.87	6.35	4.7
Grain products	80	0.47	37.60	28.0
Potatoes	91	0.37	33.67	25.1
Vegetables	20	0.32	6.40	4.8
Fruit	18	0.054	0.97	0.7
Meat and eggs	37	0.133	4.92	3.7
Fish	91	0.018	1.64	1.2
Coffee and tea	7.3	0.87	6.35	4.7
Drinking water	548	0.0055	3.01	2.2
Total			134.34	

The mean annual calcium intake is estimated to be 0.6 kg (approx. 200-250 g of creta praeparata). Hence the ratio: Bq ^{90}Sr $(kg\ Ca)^{-1}$ in total Faroese diet was 224 (6.0 pCi ^{90}Sr $(g\ Ca)^{-1}$).

Table 3.2. Estimate of the mean content of ^{137}Cs in the human diet in the Faroe Islands in 1982

Type of food	Annual quantity in kg	Bq ^{137}Cs per kg	Total Bq ^{137}Cs	Percentage of total Bq ^{137}Cs in food
Milk and cream	146	3.33	486.2	25.8
Cheese	7.3	0.076	0.6	0
Grain products	80	0.57	45.6	2.4
Potatoes	91	4.4	400.4	21.2
Vegetables	20	0.053	1.1	0.1
Fruit	18	0.038	0.7	0
Meat and eggs	37	24.6	910.2	48.2
Fish	91	0.26	23.7	1.3
Coffee and tea	7.3	2.53	18.5	1.0
Drinking water	548	0.0014	0.8	0
Total			1887.8	

The mean annual intake of potassium is estimated to be approx. 1.2 kg. Hence the ratio: Bq ^{137}Cs (kg K)$^{-1}$ becomes 1573 (42.5 pCi ^{137}Cs (g K)$^{-1}$).

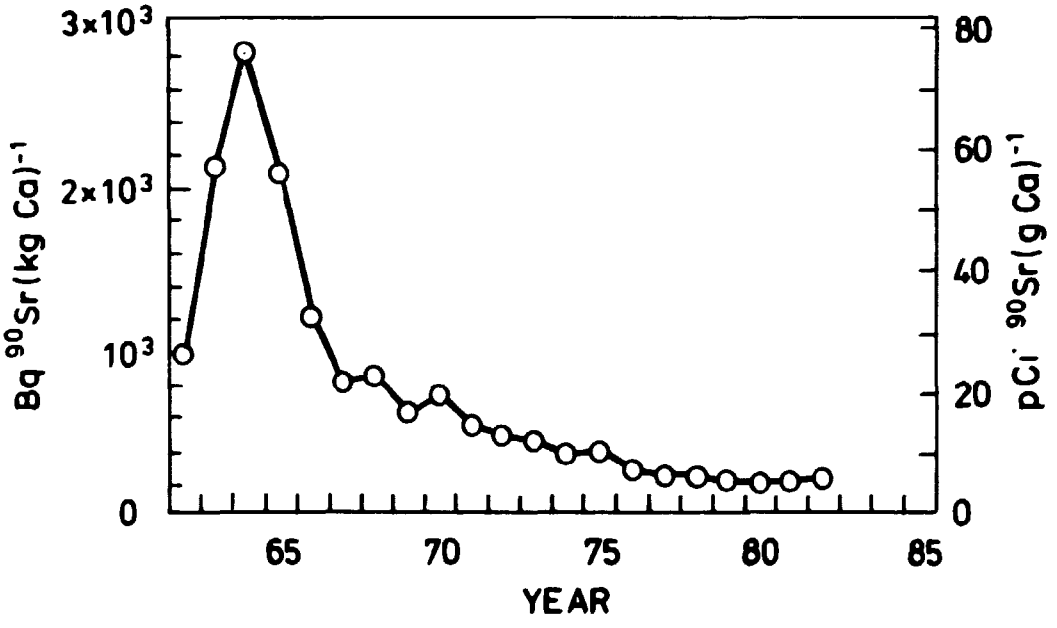

Fig. 3.1. Strontium-90 in Faroese diet, 1962-1982.

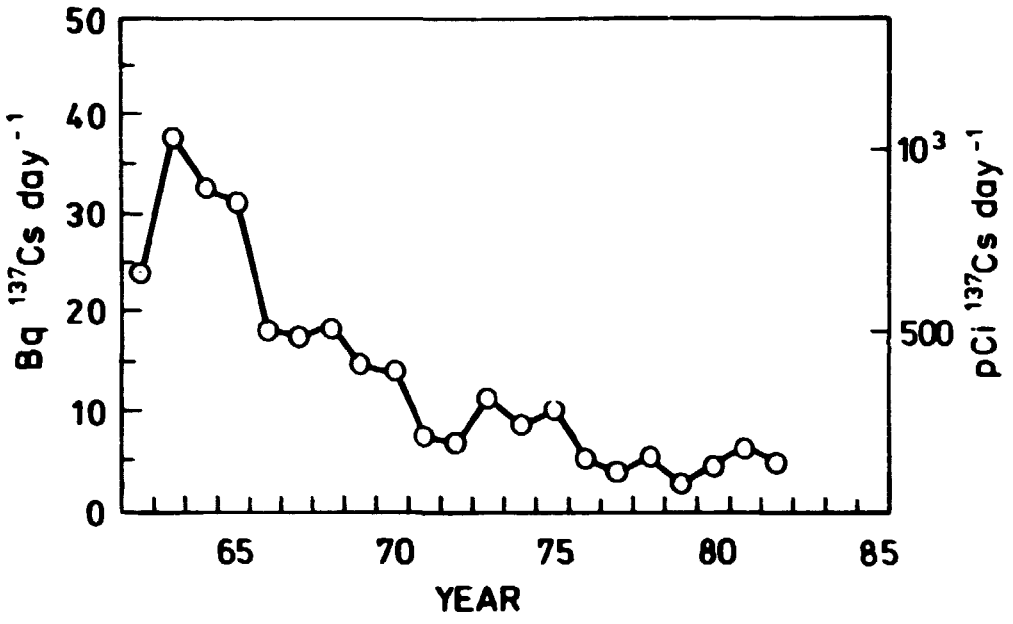

Fig. 3.2. Cesium-137 in Faroese diet, 1962-1982.

3.11. Discussion

Figures 3.1 and 3.2 show the Faroese diet levels since 1962.

The 1982 ^{90}Sr level in the total diet was a little higher than the 1981 concentration, but the ^{137}Cs level was lower than that observed in 1981.

The main contributors to the ^{90}Sr content in the Faroese diet were milk products, cereals and potatoes, which together accounted for approximately 83% of the total ^{90}Sr content in the diet in 1982. As regards ^{137}Cs, milk products, meat (lamb) and potatoes were the most important contributors. In 1982, 95% of the total ^{137}Cs content in the diet originated from these products.

The Faroese mean diet contained 1.4 times as much ^{90}Sr and approximately 12 times as much ^{137}Cs as the Danish diet in 1982[2].

As earlier[1] mentioned, the year-to-year variations in the ^{137}Cs estimates for Faroese diet are markedly influenced by the mutton and potatoe samples obtained for analysis.

4. CONCLUSION

4.1.

The ^{90}Sr fallout rate in the Faroes in 1982 was approximately 6 Bq ^{90}Sr m^{-2} (0.16 mCi km^{-2}). The accumulated fallout by the end of 1982 was estimated at approximately 3600 Bq ^{90}Sr m^{-2} (98 mCi km^{-2}) (the mean at Thorshavn and Klaksvig).

4.2.

The mean level of ^{90}Sr in Faroese milk was 220 Bq $(kg\ Ca)^{-1}$ (5.9 pCi $(g\ Ca)^{-1}$). The ^{137}Cs concentration was 4400 Bq ^{137}Cs m^{-3} (119 pCi l^{-1}).

No mutton samples were obtained in 1982. Fish showed a mean level of 0.26 Bq ^{137}Cs kg^{-1} (7.0 pCi kg^{-1}).

The mean content of ^{90}Sr in drinking water was 5.5 Bq m^{-3} (0.15 pCi l^{-1}).

The mean daily per caput intakes resulting from the Faroese diet in 1982 were estimated at 0.37 Bq ^{90}Sr (9.9 pCi d^{-1}) and 5.2 Bq ^{137}Cs (140 pCi d^{-1}).

4.3.

From the measurements on Faroese human bones (mostly vertebrae), the Faroese bone level in 1982 was estimated at 60 Bq ^{90}Sr $(kg\ Ca)^{-1}$ (1.7 pCi $(g\ Ca)^{-1}$).

The mean content of ^{137}Cs in the Faroese adult was estimated at approximately 4500 Bq ^{137}Cs $(kg\ K)^{-1}$ (120 pCi $(g\ K)^{-1}$). This estimate is based on the diet estimate.

ACKNOWLEDGEMENTS

The authors wish to thank Miss Anna Holm Petersen, Mrs. Jytte Clausen, Mrs. Else Sørensen, Mrs. Anna Madsen, Mrs. Oda Brandstrup and Mrs. Helle Porsdal for their conscientious performance of the analyses.

Our special thanks are due to the staff of the pharmacy "Tjaldur" in Thorshavn and to all other persons in the Faroes who have contributed by collecting samples.

REFERENCES

1) Environmental Radioactivity in the Faroes 1962-1978. Risø Reports Nos. 64, 86, 108, 131, 155, 181, 202, 221, 246, 266, 292, 306, 324, 346, 362, 387, 404, 422, 448 and 470 (1963-1982).
2) A. Aarkrog, L. Bøtter-Jensen, H. Dahlgaard, Heinz Hansen, J. Lippert, S.P. Nielsen and Karen Nilsson, Environmental Radioactivity in Denmark in 1982. Risø Report No. 487 (1983).
3) A. Aarkrog, Henning Dahlgaard, Heinz Hansen, Elis Holm, J. Lippert and Karen Nilsson, Environmental Radioactivity in Greenland in 1982. Risø Report No. 489 (1983).
4) E.P. Hardy, Jr., and Joseph Rivera, Fallout Program Quarterly Summary Report (March 1, 1965, through June 1, 1965). HASL-161 (1965).
5) A. Aarkrog, Environmental Studies on Radioecological Sensitivity and Variability. Risø-R-437 (June 1979).
6) G.J. Hunt, Radioactivity in Surface and Coastal Waters of the British Isles, 1981. ISSN 0142-2499, Lowestoft 1983.

APPENDIX A

The models used for the predictions shown in Table A were based on data collected 1962-1976[6]. If the predictions for previous years 1977-1980[1] were considered too, we conclude that the model for ^{90}Sr in milk overestimates the level and so do the models: for ^{90}Sr in drinking water from Klaksvig, for ^{137}Cs in milk from Tvørå and for ^{137}Cs in potatoes. The following models underestimate the concentrations: ^{90}Sr in cod fish and probably also ^{137}Cs in milk from Klaksvig.

Table A. Comparison between observed and predicted ^{90}Sr and ^{137}Cs concentrations in Faroese samples collected in 1982

Sample	Unit	Observed ±1 S.E.	Number of samples	Predicted	Obs./pre. ±1 S.E.	Model in ref. 6
Drinking water, Thorshavn	Bq ^{90}Sr m^{-3}	9.6 ±1.1	2	16.4	0.59±0.07	C.1.4.1 No. 9
- " - , Klaksvig	- " -	1.7 ±0.3	2	2.4	0.71±0.13	- " - No. 10
- " - , Tvørå	- " -	5.3 ±0.3	2	4.1	1.29±0.07	- " - No. 11
Sea water	- " -	3.3 ±0.2	4	2.34	1.41±0.09	C.1.5.1 No. 3
Rye bread	Bq ^{90}Sr kg^{-1}	0.35	1	0.41	0.85	C.2.3.1 No. 6
White bread	- " -	0.24	1	0.13	1.85	- " - No. 7
Rye bread	Bq ^{137}Cs kg^{-1}	0.43	1	0.49	0.88	- " - No. 8
White bread	- " -	0.23	1	0.14	1.64	- " - No. 9
Grass	Bq ^{90}Sr (kg Ca)$^{-1}$	4600 ±1600	2	6360	0.72±0.25	C.2.4.1 No. 4
- " -	Bq ^{137}Cs (kg K)$^{-1}$	2360 ±1340	2	1580	1.49±0.85	C.2.4.2 No. 3
Potatoes	Bq ^{90}Sr kg^{-1}	0.37	1	0.20	1.85	C.2.5.1 No. 11
- " -	Bq ^{137}Cs kg^{-1}	4.4	1	6.8	0.65	C.2.5.3 No. 8
Brown algae	Bq ^{90}Sr (kg Ca)$^{-1}$	20	2	114	0.18	C.2.7.1 No. 5
Milk	- " -	220 ±10	12	390	0.56±0.03	C.3.3.1 No. 1
Milk Thorshavn	Bq ^{137}Cs m^{-3}	2300 ±210	12	2485	0.93±0.08	C.3.3.2 No. 7
Milk Klaksvig	- " -	5200 ±320	12	2240	2.32±0.14	- " - No. 9
Milk Tvørå	- " -	5800 ±580	12	12400	0.47±0.05	- " - No. 11
Cod fish	Bq ^{90}Sr (kg Ca)$^{-1}$	124 ±22	7	30	4.1 ±0.7	C.3.5.1 No. 3
- " -	Bq ^{137}Cs kg^{-1}	0.26 ±0.02	7	0.22	1.18±0.09	C.3.5.2 No. 2

APPENDIX B

Sea water and biota collected in northern U.K. in June 1982

In cooperation with Risø National Laboratory the University of Lund collected environmental samples in northern U.K. (cf. Fig. 1) in June 1982. The samples were all collected from shore and the purpose was to study radioactive contamination in biota and sea water.

Besides nuclear weapons fallout there are two important sources to anthropogenic radioactivity in northern U.K.: the BNFL Sellafield reprocessing plant and the UKAEA Dounreay facility.

We related the concentrations in sea water Fucus vesiculosus and Mytilus edulis to the distance (by the sea) from Sellafield (cf. Figs. 4-8). The regression lines are best described by power functions, and it is remarkable that for all radionuclides and samples examined the activity concentrations are inversely proportional to the distance to a good approximation, i.e. the exponent is approximately -1. There are, however, some significant differences between radionuclides as is demonstrated in Fig.7, where the ^{241}Am to $^{239,240}Pu$ ratio decreases with the distance from Sellafield. This decrease may be due to the lower solubility (higher K_D) of Am compared with Pu. Hence an increasing proportion of the Am will go into the sediments when we move from the discharge point. We may expect to see a similar effect if we compare Pu with Cs.

The exponents for Pu in sea water and in Fucus actually suggest a more rapid decrease in Pu concentration with distance from Sellafield than is observed for ^{137}Cs (cf. Figs. 4-6). Plutonium in Mytilus edulis seems to decrease more rapidly with distance from Sellafield than Pu in Fucus. As Mytilus gets its Pu from suspended matter whereas Fucus depends upon the Pu in solution, we may conclude that particulate Pu decreases more

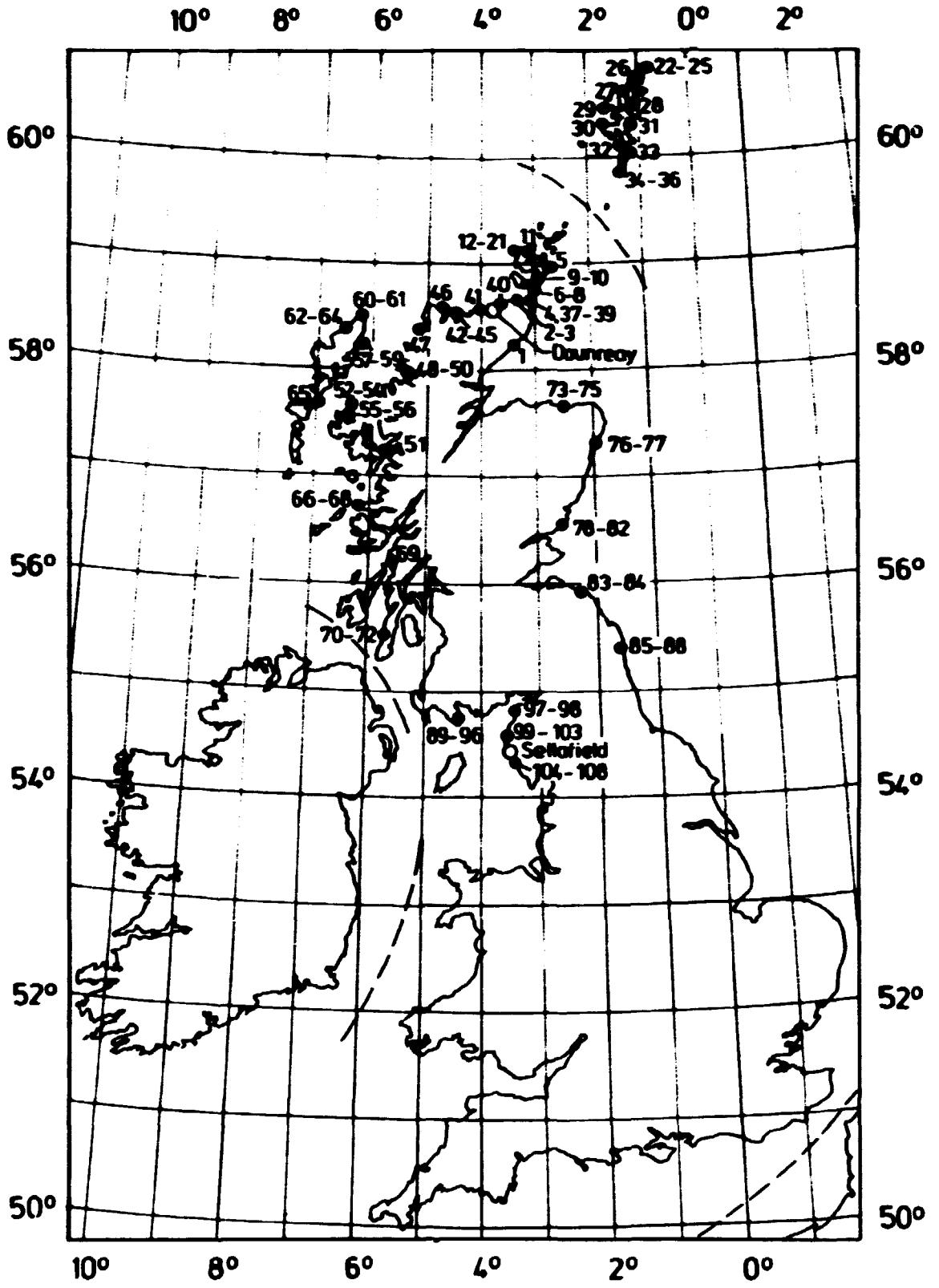

Fig. B.1. Sampling location (station No.) June 1982.

rapidly with distance from the discharge point than does soluble Pu.

When we approach Dounreay in northern Scotland the Pu and Am concentrations in the marine environment increase again. The $^{238}Pu/^{239,240}Pu$ ratio, which has remained nearly constant (~ 0.24) the whole way from Sellafield, increases sharply by a factor of two in the neighbourhood of Dounreay. The influence of Dounreay discharge is detectable out to a distance of at least 78 km (Table B.2). There seems to be no influence from Dounreay on the Sellafield ^{137}Cs and ^{90}Sr levels, but the ^{60}Co concentration near Dounreay is enhanced.

Although the distance from Sellafield to the Shetland Islands is shorter than that to the locations on the Scottish east-coast, the latter show higher concentrations than the former, because the current runs clockwise close to Scotland. The results from the Shetland Islands have therefore not been included in the distance relations.

The Lowestoft Laboratory[6] monitors the radioactivity in surface and coastal waters of the British Isles. The latest report covers 1981. If we compare the present results with those from that year we find good agreement between samples collected close to each other from the two years.

The present data may be used to calculate concentration ratios of biota to sea water. We may do this by two procedures. We can either use the mutual values at each location or we can integrate the expressions for Fucus (Tables 5 and 6) and divide by the integrals obtained from the water concentrations in Fig. 4 (cf. Table B.44).

These concentration ratios may be compared with those obtained in Iceland in 1981 (cf. Risø Report R-470, Table C.3)[1] where we found 260 for ^{137}Cs and 0.46×10^4 for $^{239,240}Pu$. It is interesting that Pu and Am in Table B.44 show similar concentration ratios.

Figures 9-11 show a comparison between ^{137}Cs and $^{239,240}Pu$ in Fucus vesiculosus relative to the concentrations found in other biological samples. Mytilus edulis contains nearly half the concentrations found in Fucus. Ascophyllum nodosum shows lower ^{137}Cs concentrations than Fucus. Pelvetia canaliculata showed similar concentrations as Mytilus edulis, i.e. approximately half of those found in Fucus.

Table B.1. Radionuclides in environmental samples collected in the northern U.K. 11 June 1982. Location: 58°03'N 3°30'W (Berriedale). Distance from Sellafield: 790 km. Salinity: 33-35 o/oo. Temperature: 12°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus spiralis	1	2 B	43	0.26*	0.86*	0.12
			42*			

Table B.2. Radionuclides in environmental samples collected in the northern U.K. 11 June 1982. Location: 58°31'N 3°21'W (Dunnet Head). Distance from Sellafield: 710 km. Distance from Dounreay: 78 km. Salinity: 35 o/oo. Temperature: 9.5°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus serratus	2	2.0 A			2.9	46				
		1.46*			1.55*	52*	11.5*	1.08*	2.7*	0.80*
Fucus vesiculosus	3	1.92		9.6 A	3.5	55		1.03±0.05	2.6±0.1	0.78
		0.59*	5.7*		1.00*	32*	6.5*	1.22*	2.6*	0.67*

The error term is 1 S.E. of the mean of double determinations.

Table B.3. Radionuclides in environmental samples collected in the northern U.K. June 1982. Location: 58°30'N 3°05'W (John o'Groats). Distance from Sellafield: 730 km. Distance from Dounreay: 43 km. Salinity: 35 o/oo. Temperature: 9°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	Date	^{54}Mn	^{60}Co	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water[V]	38	17			11.8	280			
Sea water[V]	39	17					0.083*	0.20*	0.052*
Fucus vesiculosus	37	17				44	0.43	1.14	0.38
			1.69*	1.59*		46*		1.28*	0.29*
Fucus vesiculosus	4	11			2.2	43		1.25*	0.33*
						45*			

[V]Unit: Bq m^{-3}

Table B.4. Radionuclides in environmental samples collected in the northern U.K. 12 June 1982. Location: 58°57'N 2°44'W (Skaill, The Orkney Islands). Distance from Sellafield: 760 km. Distance from Dounreay: 79 km. Salinity: 35 o/oo. Temperature: 10°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus spiralis	5		47	0.93*	0.16*
		0.97*	30*		

Table B.5. Radionuclides in environmental samples collected in the northern U.K. 12 June 1982. Location: 58°44'N 3°00'W (Burwick, The Orkney Islands). Distance from Sellafield: 730 km. Distance from Dounreay: 49 km. Salinity: 34 o/oo. Temperature: 9°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water[V]	7			0.18*	0.50*	0.018*
Sea water[V]	8	12.2	300			
Fucus vesiculosus	6		46		0.71*	0.088*
		1.8*	49*			

[V]Unit: Bq m^{-3}.

Table B.6. Radionuclides in environmental samples collected in the northern U.K. 12 June 1982. Location: 58°51'N 2°56'W (South of Burray, The Orkney Islands). Distance from Sellafield: 740 km. Distance from Dounreay: 56 km. Salinity: 35 o/oo. Temperature: 10°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{54}Mn	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	9		2.7 A	44	0.14*	0.60*	0.035*
Mytilus edulis	10	2.5*		17.0*		0.14*	0.025*

Table B.7. Radionuclides in environmental samples collected in the northern U.K. 13 June 1982. Location: 59°07'N 3°07'W (Evie, The Orkney Islands). Distance from Sellafield: 740 km. Distance from Dounreay: 82 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{106}Ru	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus serratus	11				58				
		0.49*	4.9*	1.34*	40*	6.1*	0.51*	1.94*	0.53*

Table B.8. Radionuclides in environmental samples collected in the northern U.K. 13 June 1982. Location: 59°07'N 3°21'W (Brough of Birsay, The Orkney Islands). Distance from Sellafield: 730 km. Distance from Dounreay: 66 km. Salinity: 34-35 o/oo. Temperature: 10°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{106}Ru	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water[7]	12			13.6	320				
Sea water[7]	13						0.16*	0.33*	0.068*
Fucus serratus	14	1.4 B		2.0 A	60		0.83±0.05	2.4±0.05	0.60
				2.0*	63*	9.8*	0.80*	2.4*	
Ascophyllum nodosum	15			1.23*	31*	3.6*	0.52*	1.48*	0.20*
Fucus spiralis	16			2.1 A	57		0.67±0.03	2.1±0.05	0.43
		0.40*		2.6*	68*	10.5*	0.81*	2.2*	0.38*
Fucus vesiculosus	17			2.5	65	13 A	0.77±0.09	2.1±0.1	
				1.66*	42*	4.1*	0.64*	1.61*	0.48*
Pelvetia canaliculata	18			1.9 A	27		0.36	1.07	0.25±0.05
				1.0*	31*		0.31*	1.09*	0.18*
Laminaria digitata	20			2.4	72	5.6 A	0.28	0.79	0.24
				2.7*	84*	11.9*		0.74*	0.20*
Halidrys siliquosa	21				49		1.23	3.9	0.85
				1.59*	54*	8.0*	1.02*	3.7*	
Patella flesh	19		6.9*	0.50*	15.0*	3.4*	0.14*	0.37*	0.28*

[7]Unit: Bq m^{-3}

The error term is 1 S.E. of the mean of double determinations.

Table B.9. Radionuclides in environmental samples collected in the northern U.K. 14 June 1982. Location: 60°48'N 0°46'W (Lamba Ness, The Shetland Islands). Distance from Sellafield: 970 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{54}Mn	^{60}Co	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water[▽]	24					1.1 A	31				
Sea water[▽]	25								0.0032*	0.031*	0.0061*
Fucus vesiculosus	22						5.6			0.24*	0.040*
							6.0*				
Cladonia	23				5.5 A		18.4	90		2.8*	0.62*
		0.84*	0.19*	13.8*	2.3*		11.8*	71*			

[▽]Unit: Bq m^{-3}

Table B.10. Radionuclides in environmental samples collected in the northern U.K. 15 June 1982. Location: 60°44'N 0°57'W (Westing, The Shetland Islands). Distance from Sellafield: 950 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	26	7.2	0.16*	0.019*
		3.9*		

Table B.11. Radionuclides in environmental samples collected in the northern U.K. 15 June 1982. Location: 60°35'N 1°11'W (West Sand Wick, The Shetland Islands). Distance from Sellafield: 930 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	27	2.7*	0.25*	0.019*

Table B.12. Radionuclides in environmental samples collected in the northern U.K. 15 June 1982. Location: 60°30'N 1°03'W (Burra Voe, The Shetland Islands). Distance from Sellafield: 940 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	28	5.3*	0.14*	0.017*

Table B.13. Radionuclides in environmental samples collected in the northern U.K. 15 June 1982. Location: 60°29'N 1°37'W (Stenness, The Shetland Islands). Distance from Sellafield: 890 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	29	4.5*	0.34*	0.023*

Table B.14. Radionuclides in environmental samples collected in the northern U.K. 16 June 1982. Location: 60°18'N 1°40'W (Melby, The Shetland Islands). Distance from Sellafield: 880 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	30	8.9	0.029*	0.26*	0.029*

Table B.15. Radionuclides in environmental samples collected in the northern U.K. 16 June 1982. Location: 60°15'N 1°09'W (Gletness, The Shetland Islands). Distance from Sellafield: 910 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	31	5.1*	0.25*	0.025*

Table B.16. Radionuclides in environmental samples collected in the northern U.K. 16 June 1982. Location: 60°06'N 1°20'W (Hamna Voe, The Shetland Islands). Distance from Sellafield: 880 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus serratus	32	3.9*	0.20*	0.31*	0.048*

Table B.17. Radionuclides in environmental samples collected in the northern U.K. 16 June 1982. Location: 60°03'N 1°12'W (Aith Wick, The Shetland Islands). Distance from Sellafield: 890 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	33	5.6*	0.34*	0.030*

Table B.18. Radionuclides in environmental samples collected in the northern U.K. 16 June 1982. Location: 59°52'N 1°18'W (Sumburgh, The Shetland Islands). Distance from Sellafield: 860 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	35	1.1 A	24			
Sea water$^{\nabla}$	36			0.0028*	0.31*	0.0019*
Fucus vesiculosus	34		4.8			
			5.4*		0.26*	0.024*

$^{\nabla}$Unit: Bq m^{-3}

Table B.19. Radionuclides in environmental samples collected in the northern U.K. 18 June 1982. Location: 58°28'N 3°42'W (Crosskirk Bay). Distance from Sellafield: 690 km. Distance from Dounreay: 5 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{54}Mn	^{57}Co	^{60}Co	^{90}Sr	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	40	3.8	3.0	26	8.5±2.3	158	30	8.8	4.1	79	220	17.2	35	25

The error term is 1 S.E. of the mean of double determinations.

Table B.20. Radionuclides in environmental samples collected in the northern U.K. 18 June 1982. Location: 58°26'N 3°59'W (Baligill). Distance from Sellafield: 680 km. Distance from Dounreay: 14 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus spiralis	41	1.55	1.65	43	4.4 A	0.81	3.8	1.47

Table B.21. Radionuclides in environmental samples collected in the northern U.K. 18 June 1982. Location: 58°25'N 4°27'W (Talmine). Distance from Sellafield: 650 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	44			16.1	370			
Sea water$^{\nabla}$	45					0.0009*	0.14*	0.009*
Fucus vesiculosus	42	0.6 A	6.4±0.4	2.6	66	0.38	1.88	0.109
Fucus serratus	43	1.1 A		3.0	67	0.46	2.01	0.122

$^{\nabla}$Unit: Bq m^{-3}

The error term is 1 S.E. of the mean of double determinations.

Table B.22. Radionuclides in environmental samples collected in the northern U.K. 19 June 1982. Location: 58°27'N 4°43'W (Sangobeg). Distance from Sellafield: 630 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	46	6.2±1.1	2.6	52	0.55	2.5	0.192

The error term is 1 S.E. of the mean of double determinations.

Table B.23. Radionuclides in environmental samples collected in the northern U.K. 19 June 1982. Location: 58°17'N 5°12'W (Tarbet). Distance from Sellafield: 590 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	47	3.6	73	0.59	2.8	0.126

Table B.24. Radionuclides in environmental samples collected in the northern U.K. 19 June 1982. Location: 57°55'N 5°26'W (Achiltibuie pier). Distance from Sellafield: 560 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	49	16.8	420			
Sea water$^{\nabla}$	50			0.016*	0.17*	0.016*
Fucus vesiculosus	48	2.8	73	0.55	2.8	0.127

$^{\nabla}$Unit: Bq m^{-3}

Table B.25. Radionuclides in environmental samples collected in the northern U.K. 20 June 1982. Location: 57°12'N 5°53'W (Kyleakin). Distance from Sellafield: 440 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	51	9.4±0.3	3.8	82	0.54	2.35	0.134

The error term is 1 S.E. of the mean of double determinations.

Table B.26. Radionuclides in environmental samples collected in the northern U.K. 20 June 1982. Location: 57°32'N 6°30'W (Score Bay). Distance from Sellafield: 480 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	52		14.2	340			
Sea water$^{\nabla}$	53				0.033*	0.16*	0.030*
Fucus vesiculosus	54	7.6±1.8	3.3	74	0.37	1.52	0.119

$^{\nabla}$Unit: Bq m^{-3}

The error term is 1 S.E. of the mean of double determinations.

Table B.27. Radionuclides in environmental samples collected in the northern U.K. 21 June 1982. Location: 57°32'N 6°32'W (Uig). Distance from Sellafield: 480 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{106}Ru	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	55	5.3±1.1		2.9	74	0.37	1.76	0.075
Mytilus edulis	56		14 A	1.52	29	0.085	0.41	0.104

The error term is 1 S.E. of the mean of double determinations.

Table B.28. Radionuclides in environmental samples collected in the northern U.K. 21 June 1982. Location: 58°11'N 6°15'W (Tiumpan Head, Isle of Lewis). Distance from Sellafield: 550 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{60}Co	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	57			10.3	240			
Sea water$^{\nabla}$	58					0.0057*	0.12*	0.016*
Fucus vesiculosus	59	5.4±0.6	0.70 A	1.26	30	0.29	1.41	0.115

$^{\nabla}$Unit: Bq m^{-3}

The error term is 1 S.E. of the mean of double determinations.

Table B.29. Radionuclides in environmental samples collected in the northern U.K. 22 June 1982. Location: 58°26'N 6°16'W (Port of Ness, Isle of Lewis). Distance from Sellafield: 580 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{60}Co	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	60	3.9±0.4	1.92	2.0	43	0.40	2.0	0.21
Mytilus edulis	61		2.0		15.0	0.057	0.32	0.084

The error term is 1 S.E. of the mean of double determinations.

Table B.30. Radionuclides in environmental samples collected in the northern U.K. 22 June 1982. Location: 58°17'N 6°41'W (Arno, Isle of Lewis). Distance from Sellafield: 570 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{60}Co	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	63			7.1	158			
Sea water$^{\nabla}$	64					0.030*	0.11*	0.015*
Fucus vesiculosus	62	3.0	3.1	1.42	33	0.22	1.07	0.094

$^{\nabla}$Unit: Bq m^{-3}

Table B.31. Radionuclides in environmental samples collected in the northern U.K. 23 June 1982. Location: 57°42'N 7°07'W (Rodel, Harris). Distance from Sellafield: 480 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	65	6.7±0.6	2.4	63	0.46	1.96	0.196

The error term is 1 S.E. of the mean of double determinations.

Table B.32. Radionuclides in environmental samples collected in the northern U.K. 24 June 1982. Location: 56°37'N 6°28'W (Point of Ardnamurchan). Distance from Sellafield: 370 km. Salinity: 34 o/oo. Temperature: 13°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	66		18.8	420			
Sea water$^{\nabla}$	67				0.066*	0.18*	0.026*
Fucus vesiculosus	68	8.7±1.3	4.0	83	0.88	3.8	0.36

$^{\nabla}$Unit: Bq m^{-3}

The error term is ± S.E. of the mean of double determinations.

Table B.33. Radionuclides in environmental samples collected in the northern U.K. 25 June 1982. Location: 56°09'N 5°23'W (Asknis Bay). Distance from Sellafield: 290 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{95}Nb	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	69	14.9±0.1	4.4 A	5.4	109	1.04	4.5	0.36

The error term is ± S.E. of the mean of double determinations.

Table B.34. Radionuclides in environmental samples collected in the northern U.K. 25 June 1982. Location: 55°27'N 5°35'W (Bellochantuy Bay). Distance from Sellafield: 210 km. Salinity: 34 o/oo. Temperature: 12°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{90}Sr	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	70		31	770			
Sea water$^{\nabla}$	71				0.070*	0.36*	0.018*
Fucus vesiculosus	72	15.4±2.8	6.4	144	0.90	4.1	0.48

$^{\nabla}$Unit: Bq m^{-3}

The error term is ± S.E. of the mean of double determinations.

Table B.35. Radionuclides in environmental samples collected in the northern U.K. 26 June 1982. Location: 57°32'N 2°33'W (Banff). Distance from Sellafield: 840 km. Salinity: 34 o/oo. Temperature: 9°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	74		12.7	310			
Sea water$^{\nabla}$	75				0.036*	0.12*	0.020*
Fucus vesiculosus	73	0.19*	1.9*	48*		0.62±0.06*	0.078±0.008*

$^{\nabla}$Unit: Bq m^{-3}

Table B.36. Radionuclides in environmental samples collected in the northern U.K. 27 June 1982. Location: 57°17'N 'O50'W (Port Erroll). Distance from Sellafield: 890 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	76	2.0*	52*	0.57*	0.092*
Fucus serratus	77		35*	0.83*	0.13*

Table B.37. Radionuclides in environmental samples collected in the northern U.K. 27 June 1982. Location: 56°26'N 2°32'W (Arbroath). Distance from Sellafield: 990 km. Salinity: 34 o/oo. Temperature: 12°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water$^{\nabla}$	80			lost	lost	
Sea water$^{\nabla}$	81	10.6	250			
Sea water$^{\nabla}$	82	spiked	290			
Fucus vesiculosus	78		35		0.48*	0.069*
Fucus serratus	79	0.61	22		0.54*	0.062*

$^{\nabla}$Unit: Bq m^{-3}

Table B.38. Radionuclides in environmental samples collected in the northern U.K. 28 June 1982. Location: 55°48'N 2°20'W (Reed Pt. Cove). Distance from Sellafield: 1050 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus serratus	83	0.30*	0.74*	17.6*	0.072*	0.32*	0.023*
Fucus vesiculosus	84		0.76*	20.5*		0.52*	0.029*

Table B.39. Radionuclides in environmental samples collected in the northern U.K. 28 June 1982. Location: 55°16'N 1°37'W (Alnmouth). Distance from Sellafield: 1110 km. Salinity: 26 o/oo. Temperature: 12°C. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Sea water^{V}	86			0.11*	0.30*	0.14*
Sea water^{V}	87	5.4	137			
Sea water^{V}	88	spiked	141			
Fucus vesiculosus	85	1.0 A	24		0.50*	0.022*
			28*			

^{V}Unit: Bq m^{-3}

Table B.40. Radionuclides in environmental samples collected in the northern U.K. 29 June 1982. Location: 54°37'N 4°19'W (North of Isle of Whithorn). Distance from Sellafield: 66 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{57}Co	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	89		6.4	23	31	88			31	610	3.6	18.2	5.5
Fucus vesiculosus	90		6.2	27	42	93		6.2 A	35	680	6.2	23	7.4
Fucus vesiculosus	91		6.2	31	43	88			33	670	7.4	34	8.7
Fucus vesiculosus	92		7.0	32	44	89	3.1 A		38	740	6.7	30	7.2
Fucus spiralis	93		5.9	25	35	72		5.8 A	29	570	6.4	27	6.7
Ascophyllum nodosum	94		3.4	18.7	28	49	1.58	4.2	23	470	4.8	22	4.9
Pelvetia canaliculata	95	0.43 A	2.6	21	32	76	1.69	6.0	16.9	330	3.6	14.3	2.7
Mytilus edulis	96		5.3		6.6	510			20	400	2.5	11.6	12.1

Table B.41. Radionuclides in environmental samples collected in the northern U.K. 30 June 1982. Location: 54°43'N 3°23'W (Beckfoot). Distance from Sellafield: 55 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{57}Co	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	97	1.4 A	4.7	21	31	152	2.7 A	53	1150	10.1	45	23
Mytilus edulis	98		4.6	8.2	9.2	580		21	450	1.72	14.3	17.8

Table B.42. Radionuclides in environmental samples collected in the northern U.K. 30 June 1982. Location: 54°27'N 3°35'W (Whitehaven). Distance from Sellafield: Approximately 23 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	^{239,240}Pu	^{241}Am
Fucus vesiculosus	99	37	70	120	300	3.9 A	11 A	71	1330		11.6	48	12.3
Fucus spiralis	100	32	50	92	250		11 A	76	1410		9.2	48	12.8
Ascophyllum nodosum	101	13.2	50	85	220	3.8 A		55	1030		14.8	31	6.8
Mytilus edulis	102	14.0			1800	75		33	660		4.7	39	26
Patella	103	8.7	30	59	1110	14.4	18.0	36	740	20 A	4.4	39	36

Table B.43. Radionuclides in environmental samples collected in the northern U.K. 30 June 1982. Location: 54°17'N 3°10'W (Seascale). Distance from Sellafield: Approximately 3 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{54}Mn	^{57}Co	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{238}Pu	^{239,240}Pu	^{241}Am
Fucus vesiculosus	104	3.5 A	9.6	56	550	900	1440	25	67	151	2600	96	71	270	84
Ascophyllum nodosum	105		7.6	40	440	750	1480	14.5	31	108	2000	71	71	270	97
Porphyra umbilicalis	106		14.5	12.8	450	900	6200	5.6 A	42	56	930	220	80	290	163
Mytilus edulis	107			29	270	520	9900		36 A	74	1240	57 A	36	133	126
Patella	108		10.2	31	240	480	2900	133	39	55	970	133	56	210	185

Table B __. Concentration ratios: Bq kg^{-1} Fucus vesiculosus dry/Bq l^{-1} sea water

Method (cf. text)	^{137}Cs	^{239,240}Pu	^{241}Am
Mutual values	178±7 (±1 SE,N=14)	(0.98±0.15) × 10^4 (±1 SE,N=14)	(0.86±0.17) × 10^4 (±1 SE,N=14)
Integration	190 (range 210-1110 km)	1.55 × 10^4 (range 210-840 km)	-

The integration ranges were within the distances where both sea water and Fucus results were available.

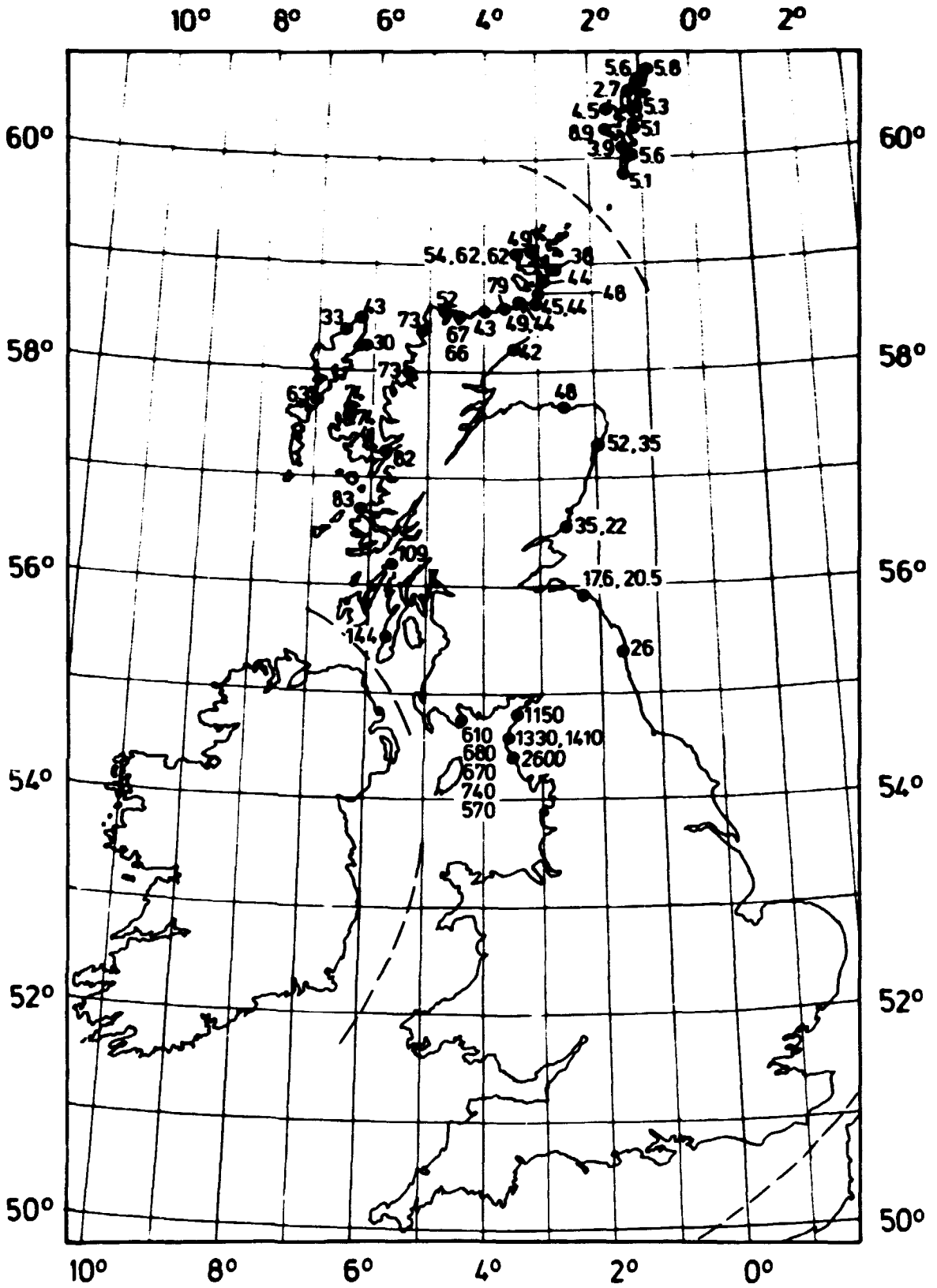

Fig. B.2. Cesium-137 in Fucus species. (Unit: Bq kg^{-1} dry weight).

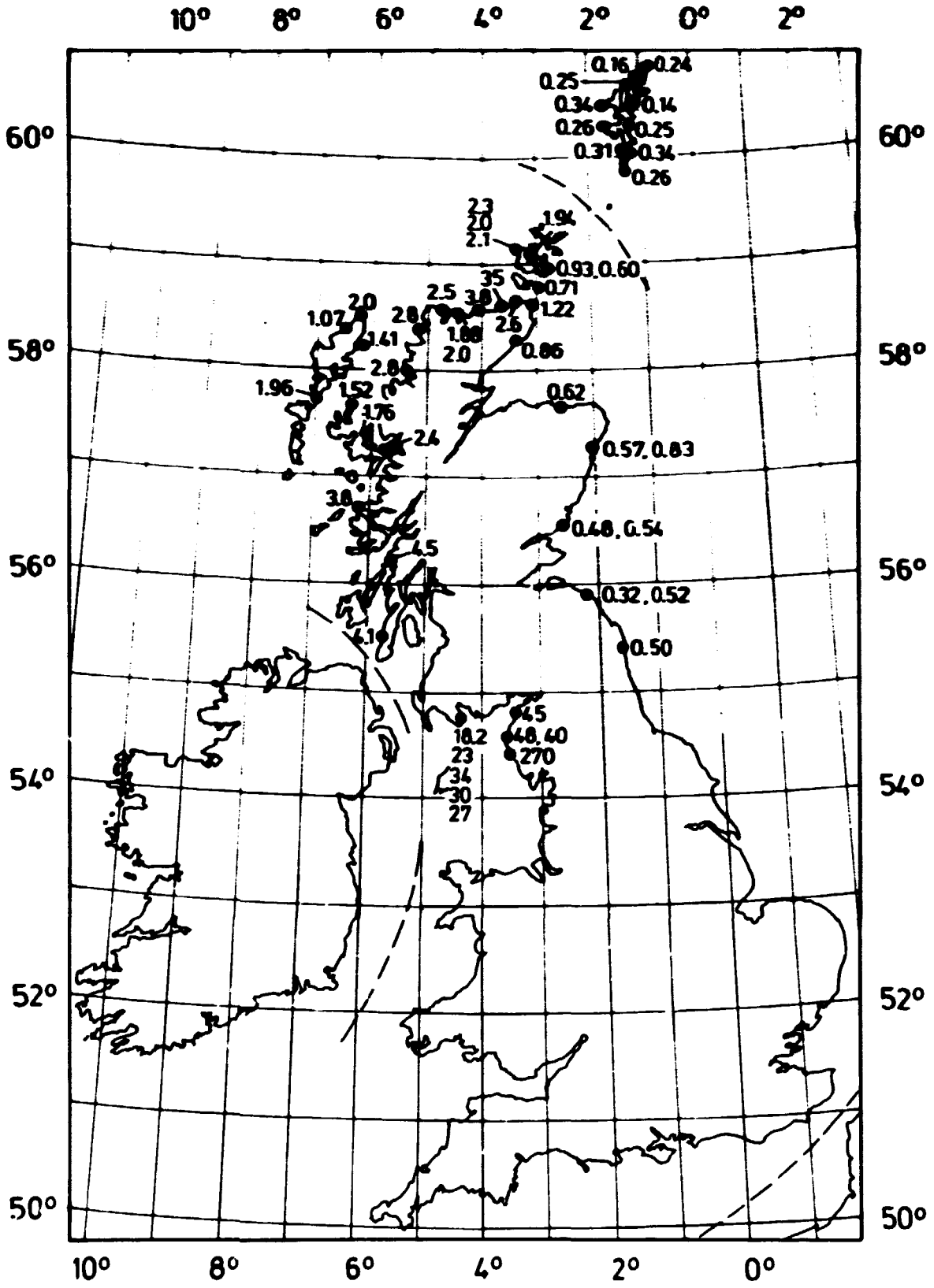

Fig. B.3. Plutonium-239,240 in Fucus species. (Unit: Bq kg^{-1} dry weight).

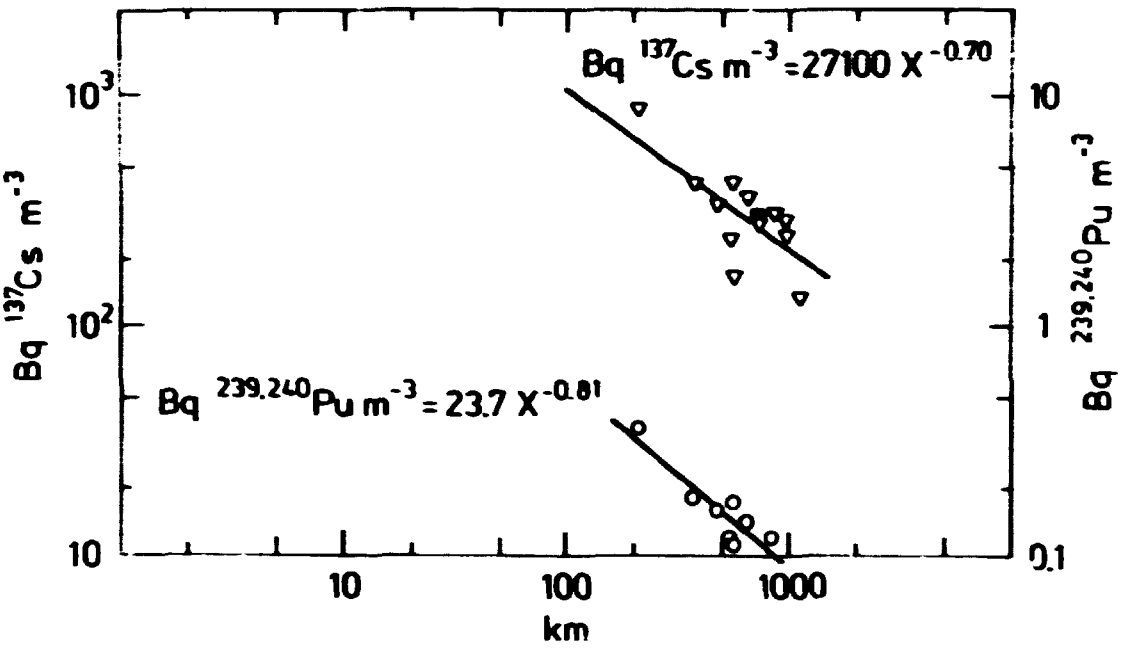

Fig. B.4. Cesium-137 and ^{239,240}Pu in coastal surface sea water collected in the Northern U.K. in June 1982 related to distance from Sellafield. (The data from the Shetland Islands were excluded and so were the Pu data within 78 km from Dounreay.)

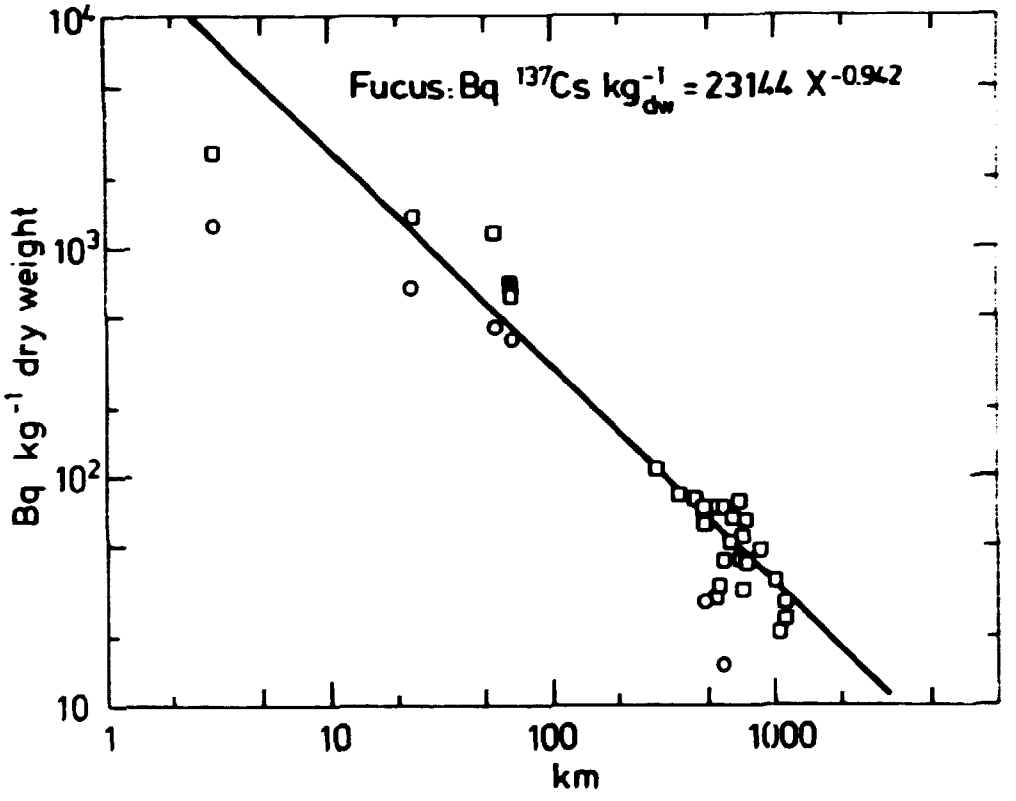

Fig. B.5. Cesium-137 in Fucus vesiculosus (□) and Mytilus edulis (o) collected in the Northern U.K. in June 1982 related to distance from Sellafield (the Shetland Islands not included).

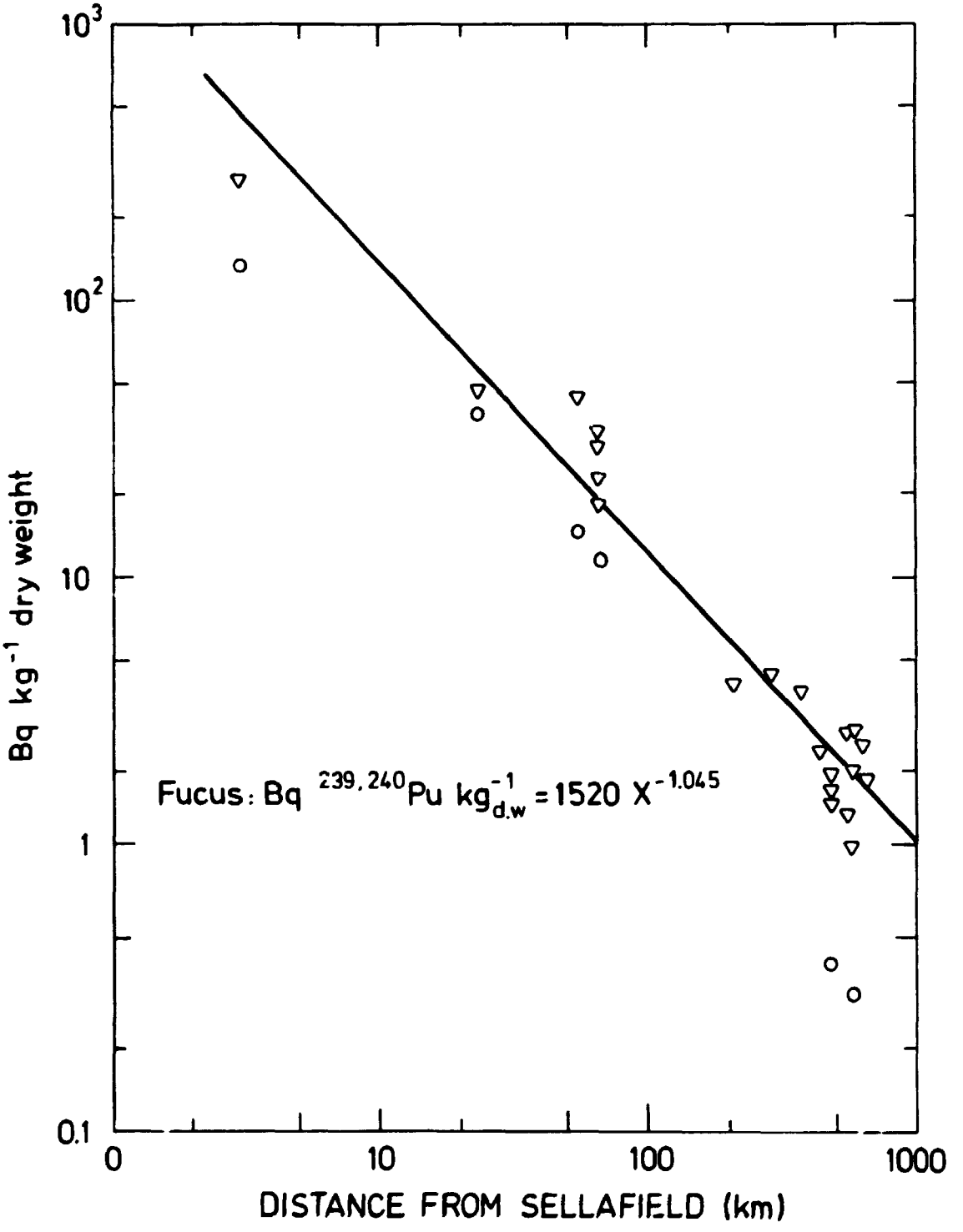

Fig. B.6. Plutonium-239,240 in Fucus vesiculosus (▽) and Mytilus edulis (o) collected in the Northern U.K. in June 1982 related to distance from Sellafield. (The Shetland Islands were not included, furthermore we have excluded the locations near Dounreay and the locations on the Scottish eastcoast.)

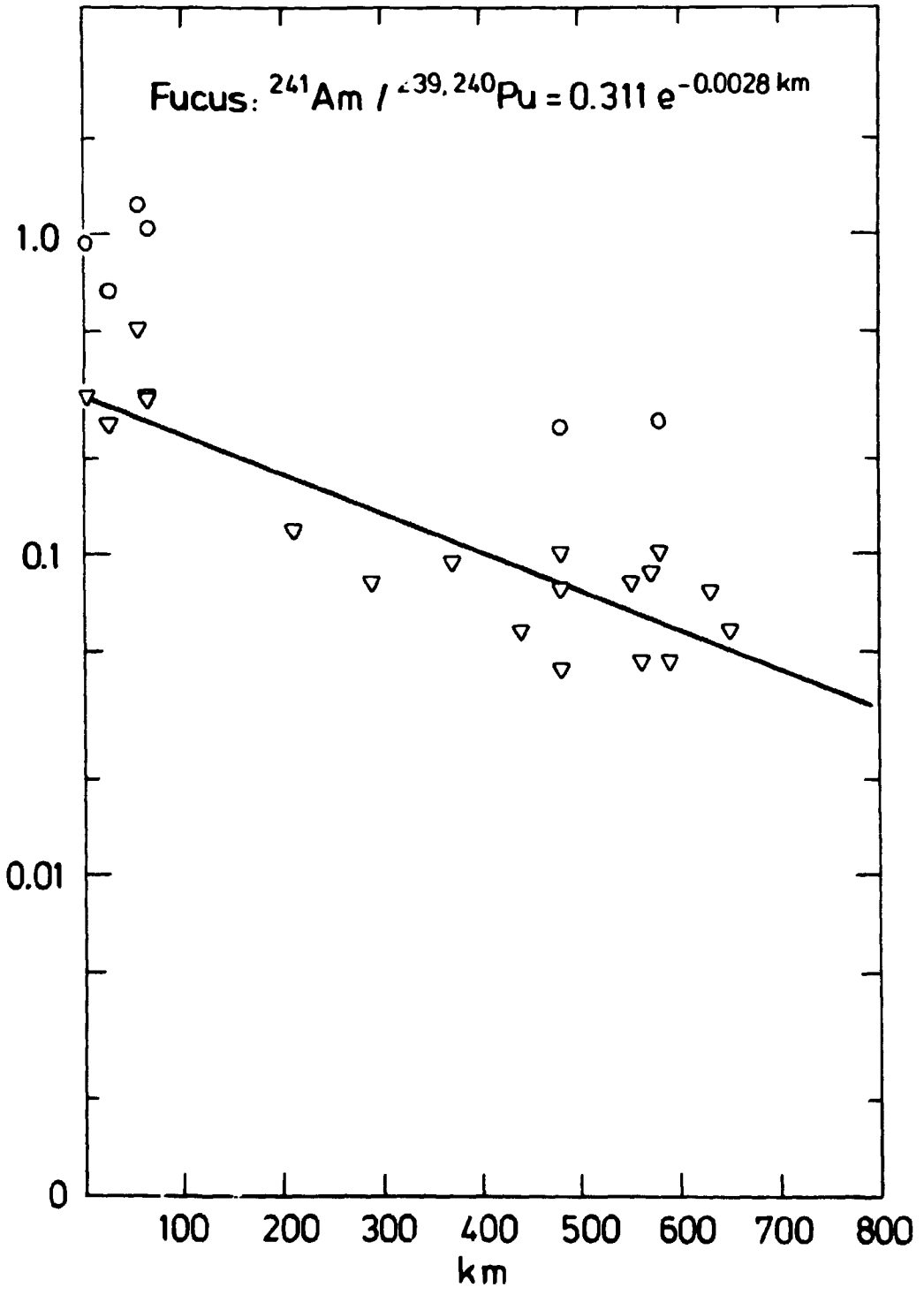

Fig. B.7. Americium-241/Plutonium-239,240 in Fucus vesiculosus (▽) and Mytilus edulis (o) collected in the Northern Scotland in June 1982 related to distance from Sellafield (cf. the remark to Fig. B.6).

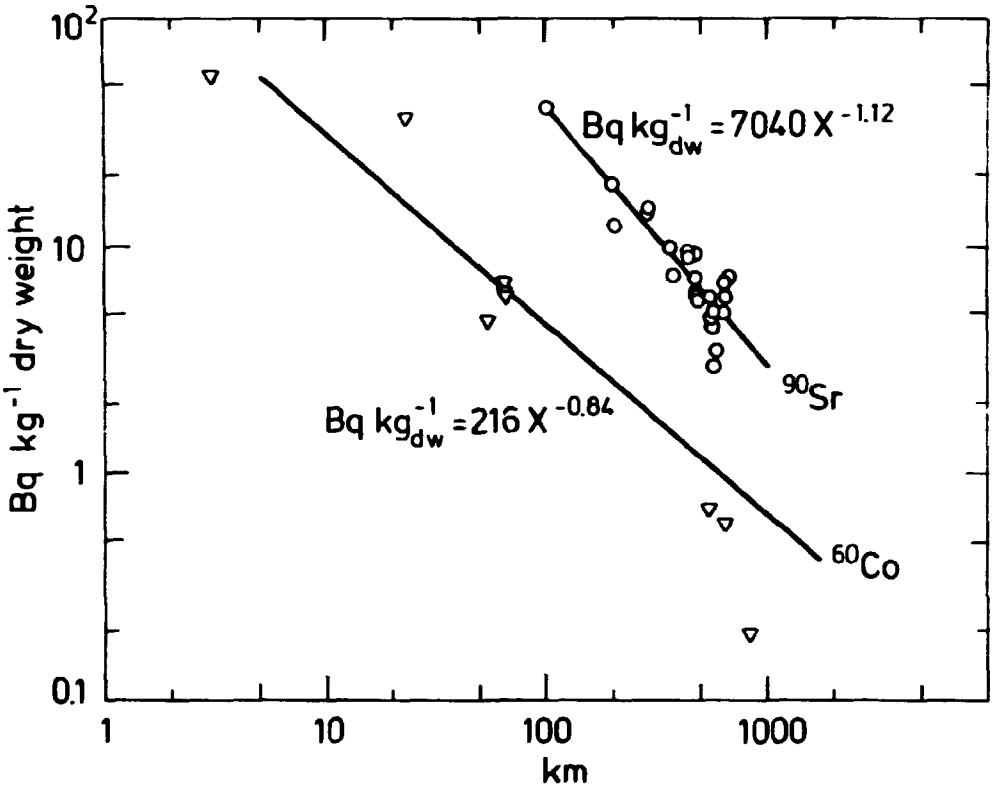

Fig. B.8. Strontium-90 and Cobalt-60 in Fucus vesiculosus collected in the Northern U.K. in June 1982 related to distance from Sellafield (locations within 78 km from Dounreay are excluded).

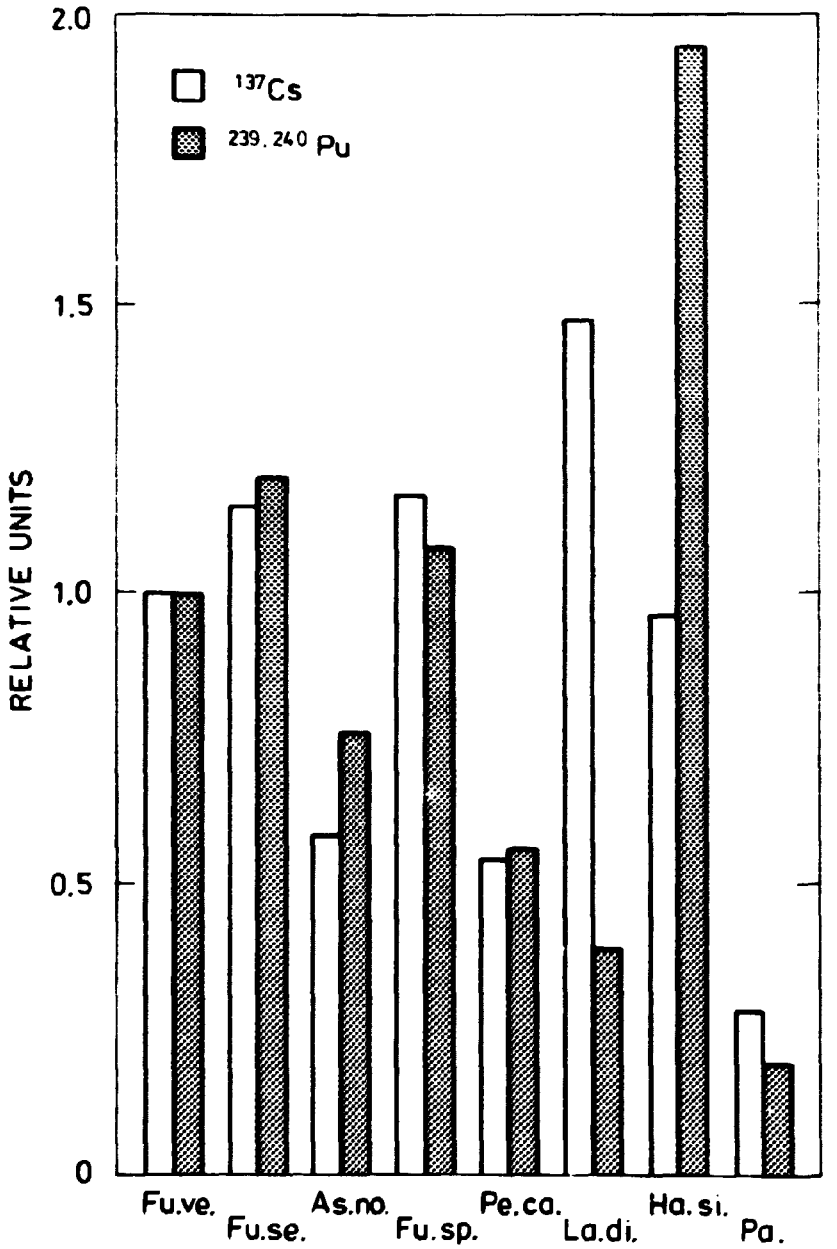

Fig. B.9. Relative ^{137}Cs and $^{239,240}Pu$ concentrations in biological samples (cf. Table B.8). Fucus vesiculosus = 1.

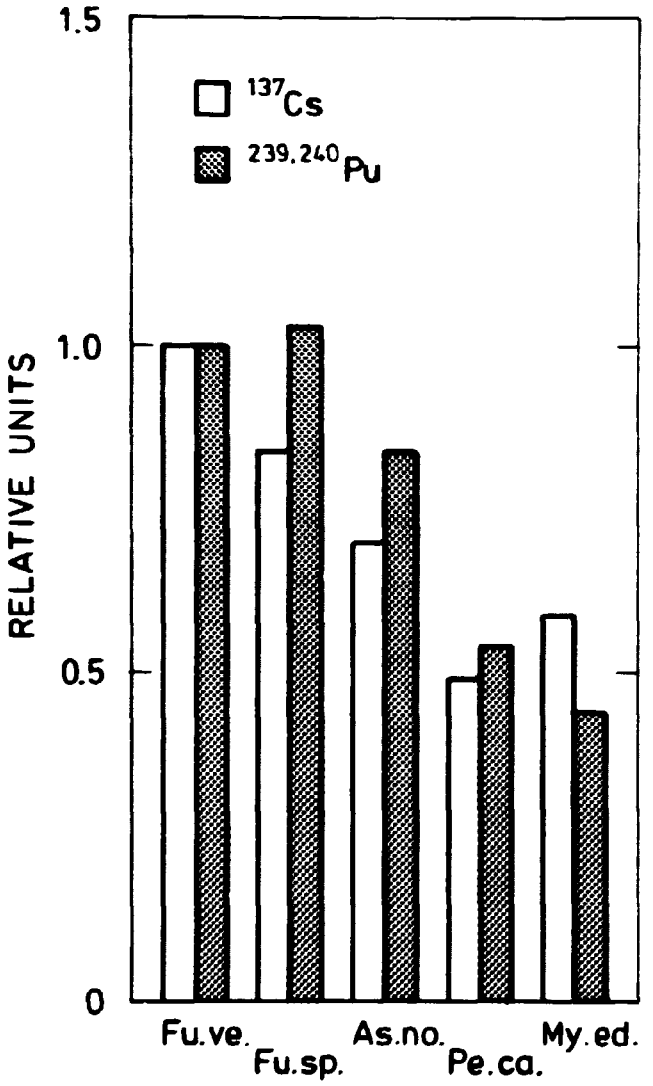

Fig. B.10. Relative ^{137}Cs and $^{239,240}Pu$ concentrations in biological samples (cf. Table B.40). Fucus vesiculosus = 1.

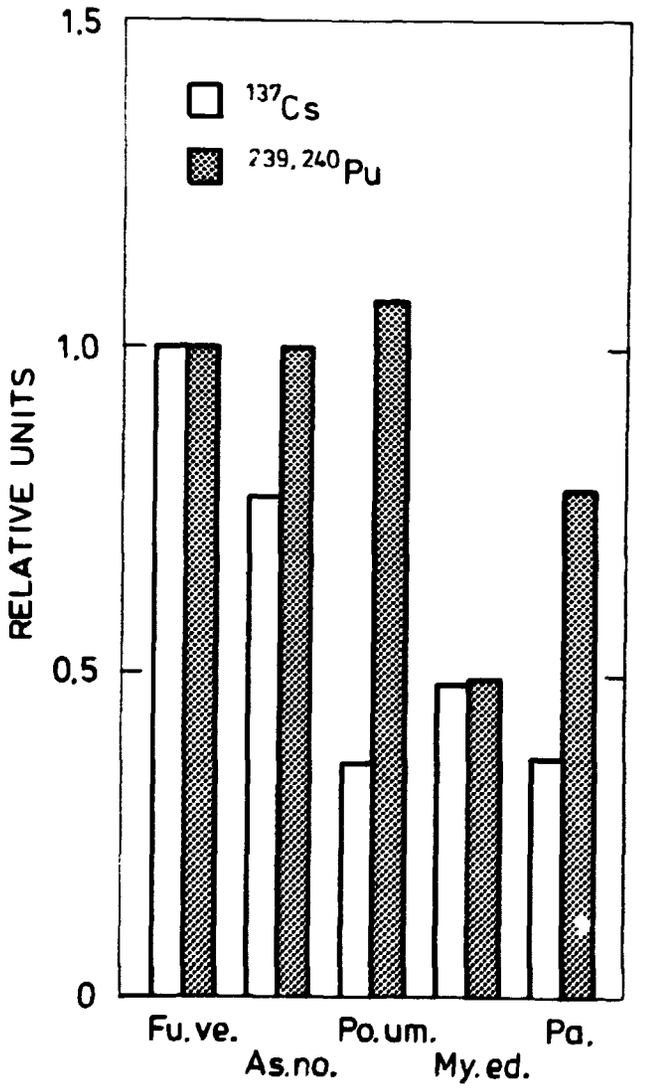

Fig. B.11. Relative ^{137}Cs and $^{239,240}Pu$ concentrations in biological samples (cf. Table B.43). Fucus vesiculosus = 1.

Risø-R-488

Environmental Radioactivity in the Faroes in 1982

ERRATA

p 43, Table B 19

Table B.19. Radionuclides in environmental samples collected in the northern U.K. 18 June 1982. Location: 58°28'N 3°42'W (Crosskirk Bay). Distance from Sellafield: 690 km. Distance from Dounreay: 5 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{54}Mn	^{60}Co	^{90}Sr	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	40	3.8	26	8.5±2.3	158	30	8.8	4.1	79	220	5.1	7.3	17.2	35	25

The error term is ± S.E. of the mean of double determinations.

p 49, Table B 40 and B 41

Table B.40. Radionuclides in environmental samples collected in the northern U.K. 29 June 1982. Location: 54°37'N 4°19'W (North of Isle of Whithorn). Distance from Sellafield: 66 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	89	6.4	23	31	88			31	610	3.6	10.2	5.5
Fucus vesiculosus	90	6.2	27	42	93		6.2 A	35	680	6.2	23	7.4
Fucus vesiculosus	91	6.2	31	43	88			33	670	7.4	34	8.7
Fucus vesiculosus	92	7.0	32	44	89	3.1 A		38	740	6.7	30	7.2
Fucus spiralis	93	5.9	25	35	72		5.8 A	29	570	6.4	27	6.7
Ascophyllum nodosum	94	3.4	18.7	28	69	1.58	4.2	23	470	4.8	22	6.9
Pelvetia canaliculata	95	2.6	21	32	76	1.69	6.0	16.9	330	3.6	14.3	2.7
Mytilus edulis	96	5.3		6.6	510			20	400	2.5	11.6	12.1

Table B.41. Radionuclides in environmental samples collected in the northern U.K. 30 June 1982. Location: 54°43'N 3°23'W (Beckfoot). Distance from Sellafield: 55 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{134}Cs	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	97	4.7	21	31	152	2.7 A	53	1150	10.1	65	23
Mytilus edulis	98	4.6	8.2	9.2	580		21	450	1.72	14.3	17.8

p 50, Table B 43

Table B.43. Radionuclides in environmental samples collected in the northern U.K. 30 June 1982. Location: 54°17'N 3°30'W (Seascale). Distance from Sellafield: Approximately 3 km. Unit: Bq kg^{-1} dry weight.

Species	Station No.	^{54}Mn	^{60}Co	^{95}Zr	^{95}Nb	^{106}Ru	^{110m}Ag	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce	^{154}Eu	^{155}Eu	^{238}Pu	$^{239,240}Pu$	^{241}Am
Fucus vesiculosus	104	3.5 A	56	550	900	1440	25	67	151	2600	96	16.8	21.0	71	270	84
Ascophyllum nodosum	105		40	440	750	1480	14.5	31	108	2000	71	14.0	14.3	71	270	97
Porphyra umbilicalis	106		12.8	450	900	6200	5.6 A	42	56	930	220	13.4	15.7	80	290	163
Mytilus edulis	107		29	270	520	9900		36 A	78	1240	57 A			34	133	126
Patella	108		31	240	480	2900	133	39	55	970	133	19.5	17.4	54	210	185

Sales distributors:
Jul. Gjellerup, Sølvgade 87,
DK-1307 Copenhagen K, Denmark

Available on exchange from:
Risø Library, Risø National Laboratory,
P.O.Box 49, DK-4000 Roskilde, Denmark

ISBN 87-550-0951-4
ISSN 0106-2840